# Local Factor Market Distortions in China

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## 1. Introduction

China over the last 25 years has undergone massive reform in output markets and experienced a PPP income growth rate of about 11% a year (WDI, 2017). While growth has been extraordinary, two sets of reforms have been much slower. First are factor markets reforms for capital, labor and land markets. Second are governance reforms in the administrative structure of the urban political hierarchy. The current situation in capital markets tends to favor certain cities, particularly big political players in the administrative hierarchy with lower costs of capital, as well as some smaller, heavy industry cities which have a history of strong state ownership of enterprises. In land markets, more ambitious local political leaders have promotion incentives to manipulate local land markets to finance infrastructure investments, with the intention of promoting industrial growth, potentially at the expense of local consumer welfare. These distortions incur efficiency losses, with lowered returns overall to capital owners, misallocated land, and lower welfare of workers. Cities which are favored in capital markets tend to be oversized, contributing to welfare losses. There are also institutional frictions in labor markets inhibiting movement of workers from low productivity to higher productivity locations, resulting in welfare losses compared to a world without institutional frictions.

While our focus, as an example, is on China, some of the issues are well known and apply to many countries. Favoritism in more general terms is a focus of the literatures on urban bias (Lipton 1977) and big city bias (Renaud, 1980, Ades and Glaeser, 1995, Moomaw and Shatter, 1996, Davis and Henderson 2003, Duranton 2007). Papers show empirically that favored cities, with national capitals being a prime example, tend to be larger than other cities ceteris paribus, especially in non-democratic countries. For national capitals that can lead to excessive urban primacy in a country and result in reduced economic growth (Henderson, 2003 and Castells-

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Quintana 2017). Chen et al (2017) show for China that cities which enjoyed lower prices of capital in the late 1990's and early 2000's grew faster than other cities from 2000-2010. Henderson and Kuncoro (1996) for Indonesia argue that capital markets and other biases draw firms into favored cities.

The local political side and manipulation of local land markets is more China specific but contains elements that may seem familiar: for the USA, historical over-zoning of land for industrial use in certain cities and mayors facing a perceived trade-off in introducing specific policies which may promote local industrial growth, at the expense of allocating resources to improve the quality of life of residents. Business developers may have also played a salient role in influencing local land development policies (e.g., Molotch, 1976; Logan and Molotch, 1987; Sole-Olle and Viladecans-Marsal, 2012).[2]

In this paper we tackle the issues of favoritism of certain cities, local political manipulation of land markets and migration frictions in a comprehensive fashion using a structural general equilibrium model of China based on prefecture level data. We first draw out key features of the current (2010) equilibrium. Then we calibrate the key parameters of the model using data from the three factor markets. Specifically, for the capital market, we use the estimated cost of capital city-by-city based on firm level information from China's industrial survey data. For the labor market, the 2010 and 2000 population censuses are used to estimate the migration cost from city to city. For the land market, we use the hedonic prices of both industrial land and residential land constructed from a large land transaction dataset covering Chinese cities nationwide. Finally, we analyze counterfactuals to assess the impact of factor market reforms on where people reside, returns to capital, overall welfare of workers, and inequality across space.

A key contribution is that we model the political process of why land is misallocated within cities. We assume local leaders maximize a function that has weights for city GDP and for the welfare of the representative local resident. The weight on GDP reflects the notion discussed below that local leaders' potential for promotion depends on the economic performance of the

[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 of local economic growth. Logan and Molotch (1987) argue that "urban growth machines", which combine real estate, banking, and commercial interests to support the expansion of cities, are a typical feature of many U.S. cities. However, these arguments do not provide a formal theory or empirical analysis of the role of developers in the formation of land development policies. Sole-Olle and Viladecans-Marsal (2012) find some indirect empirical evidence pointing to the influence of developers on local land development regulations in Spain.

locality they are currently governing. The key inter-related instruments a local leader has are twofold. First is land allocation, potentially favoring industry to encourage industry growth, as opposed to allocating land for residential use. Second is local revenue raised from land sales revenues which are used to finance infrastructure relevant to firms. A local leader manipulates the local land market to achieve their desired allocations, and that manipulation is reflected in the relative price of industrial land to residential land. In a novel approach, we estimate these relative weights for each city using the hedonic price information and structure of the model.

Major findings from the counterfactual analysis are as follows. First, we equalize the capital price across cities while keeping the total national capital supply unchanged; that increases total output and social welfare by 11.5% and 4.4% respectively, compared to the current state. Second, we further correct the distortion of local leaders' preference towards GDP, so that the objective of each local leader switches to just maximizing the welfare of city residents. Then the local leader will cease to oversupply industrial land relative to residential land. As a result, total output will increase by 9.1% over the current situation, a bit lower than the first case, but social welfare will increase by 13.4%, much higher than the first case. Finally, if on top on the above two cases, we go even further by lowering migration frictions for high friction provinces, then total output increases by 15.0%, compared to the current state. Such significant improvement comes from improved allocations allowing workers to move to higher productivity locations for themselves. We do note that while the reforms generally raise welfare there are losers, especially people living in older more remote industrial cities housing subsidized state owned firms, who now face higher prices of capital. These losses to these places mean inequality rises with reforms.

Our paper contributes to the literature by providing a spatial general equilibrium framework to study the misallocation of three key factor markets and its welfare implications. There are many spatial general equilibrium models of the within country distribution of resources (for example Allen and Arkolakis 2014, Hornbeck and Donaldson 2016, Alder 2017, Redding 2016 and Bryan and Morten 2018). The closest paper to ours is by Tombe and Zhu (2018), although we eschew explicit modeling of transport costs. Tombe and Zhu find that reducing trade and migration frictions in China has important welfare implications. We investigate the impact of removing favoritism in the capital market and correcting the misallocations of land due to local governments manipulating markets to enhance city GDP at

the expense of residents' welfare (Tao, et al., 2010). And we study how impacts are amplified by lowering migration frictions.

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

## 2. Institutional Background

The institutional context we discuss covers capital markets, the urban hierarchy, politics and governance of cities, land markets, and financing of infrastructure investments. The slow reform in capital markets has been written about widely (Hsieh and Klenow, 2009, Gao 2013, Chen, Henderson and Cai, 2017, Brandt, Tombe and Zhu (2013), Jefferson and Singhe 1999). The key issue is that banks are state owned and loans are often made on political grounds. Banks favor state owned firms nationally as is well known (Dollar and Wei 2007), but also certain cities (Chen at al 2017) based in part on place in the urban administrative hierarchy (Liu, 2007). We will show that provincial level cities and many provincial capitals face distinctly lower capital market prices.

All this plays out in an urban administrative hierarchy which has three distinct levels: provincial level cities of which there are 4, provincial capitals of which we will have 25, and ordinary prefectures. In addition, there are 5 sub-provincial level prefectures which enjoy similar political power as provincial capitals in the hierarchy; we will lump those together with provincial capitals. In the paper we work with the 266 prefectures in Han China which covers about 90% of China's population, avoiding minority areas due to differential governance and lack of data. Many governmental functions are decentralized in China to first the provinces and then to prefectures. 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 party. For the urban administrative hierarchy, provincial level cities (Beijing, Shanghai, Tianjin and Chongqing) have the same powers as provinces, enjoying greater revenue sources and fiscal

freedoms. Then come provincial capitals where many decisions about what ordinary prefectures within the provinces can do and what monies they receive are made, including for example major bank lending decisions.

For land, urban land is owned and allocated by the state and prefectures are responsible for oversight of rural land usage. Land is sold by the state as leasehold, generally at auction but also through direct sale negotiations. The literature argues that industrial land allocations and low pricing have been used by prefectures to compete for manufacturing investment, viewed as the vehicle of local economic growth (Tao, Liu and Cao, 2010 and Cao, Feng and Tao, 2008). The literature gives the data to show that land leasehold sales revenues have funded over 50% infrastructure investments in the 1990's and 2000's, with the remainder financed by loans using land as collateral (Peterson, 2006 and Ding, 2003). A third branch of the literature shows that local political leaders (party secretaries in particular, as well as mayors) have strong incentives to focus on enhancing GDP, given GDP performance is a key element on which they are graded and evaluated for promotion (Li and Zhou, 2005, Chen, Li and Zhou, 2005). However the score card does seem to be changing with some focus on environmental issues (Zheng, Kahn, Sun and Luo 2014). Wang, Zhang and Zhou (2018) take these arguments further as we will discuss in more detail later to argue that there is an age range of local leaders when promotion is most likely and the incentive to focus on growing GDP is highest. Given these literatures, in the model we assume land revenues are the source of infrastructure investment, that investment is intended to improve productivity of firms, and local leaders maximize a function that has weights for GDP and for the welfare of the representative local resident. We will estimate these relative weights for each city.

For labor, migration restrictions are a subject of much analysis (Chan 2010, Au and Henderson 2006a, 2006b, Cai, 2006, and Tombe and Zhu 2018). While most formal restrictions under the hukou registration system were lifted by the early 2000's, informal restrictions keep the cost of moving extremely high, especially across provinces in rural to urban moves (Tombe and Zhu 2018). Informal restrictions on immigrants are sometimes described as raising the doorsill especially in the biggest cities (Cai, 2006) and include poor access to public services such as schooling and to public utilities (e.g., indoor running water) in areas into which migrants are funneled (Zheng et. al. 2009). Here we model and estimate migration frictions which limit the impact of reforms. We do look at one counterfactual based on a central government intention

to divert migrants away from the largest cities by lowering the cost of migrating to less accessible and hinterland locations.

## 3. Model

In this section we develop a spatial general equilibrium model. We consider a system of N cities with a fixed national population where workers can move across cities at certain migration costs. We start with the production sector and then turn to the housing sector and individual worker's utility maximization, public goods, the local government's objective function, and the migration decisions of workers. Equilibrium conditions of the model will be derived at the end.

### 3.1 Production

Consider city $i$. We shall suppress the subscript of the city until needed. The production function of a representative firm in city $i$ is given by

$$\mathrm{Y} = \mathrm{AL}^{\epsilon} X_I^{\alpha_X} L^{\alpha_L} K_I^{\alpha_K}, \qquad (1)$$

with $\alpha_\mathrm{X} + \alpha_\mathrm{L} + \alpha_K = 1$, where $X_I$, $L$, and $K_I$ are respectively land, effective labor, and capital in the city devoted to the production of the numeraire industrial good $Y$. $\epsilon$ is the degree of external economies of local industry scale, with scale given by total effective labor in the city. We could add a structure of goods' varieties and transport costs but for the experiments we run it would add little of direct relevance. Given the factor prices and the effective labor $L$ (to be defined later), with profit maximization under perfect competition, we can derive the unit cost function and factor demands. The unit cost is equal to price under perfect competition, which is normalized to 1. Rearranging terms, we obtain the following expression for wage per unit of effective labor, $w$:

$$\mathrm{w} = \alpha_L^{\frac{1}{\alpha_L}} A^{\frac{1}{\alpha_L}} L^{\frac{\epsilon}{\alpha_L}} \left(\frac{1}{P_X^I}\frac{\alpha_X}{\alpha_L}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{1}{r}\frac{\alpha_K}{\alpha_L}\right)^{\frac{\alpha_K}{\alpha_L}}, \qquad (2)$$

where $P_X^I$ and $r$ are respectively the price of industrial land and capital in city $i$which are city specific.

We can derive the demand for industrial capital and land relative to the demand for labor as $\frac{w}{r} = \frac{\alpha_L}{\alpha_K}\frac{K_I}{L}, \frac{w}{P_X^I} = \frac{\alpha_L}{\alpha_X}\frac{X_I}{L}$. Then we substitute in the wage expression to get the demand for

industrial capital and land in the city, as a function of industrial land price, capital price, and total effective labor

$$K_I = A^{\frac{1}{\alpha_L}} \alpha_K^{\frac{\alpha_K+\alpha_L}{\alpha_L}} \alpha_X^{\frac{\alpha_X}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} P_X^{I\,-\frac{\alpha_X}{\alpha_L}} \mathrm{r}^{-1-\frac{\alpha_K}{\alpha_L}} \qquad (3)$$

$$X_I = \alpha_{\mathrm{X}}^{\frac{\alpha_L+\alpha_X}{\alpha_L}} \alpha_K^{\frac{\alpha_K}{\alpha_L}} A^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} \mathrm{P}_{\mathrm{X}}^{\mathrm{I}\,-1-\frac{\alpha_X}{\alpha_L}} r^{-\frac{\alpha_K}{\alpha_L}} \qquad (4)$$

### 3.2 Housing sector and the base utility of individual workers

Assume a competitive housing sector. For a representative real estate developer, housing services are produced according to the following function:

$$H = X_R^{1-\rho} K_R^{\rho}, \qquad (5)$$

where $X_R$ is residential land and $K_R$ is residential capital. Given the price of housing $P$, the price of residential land, $P_X^R$, and the price of capital, $r$, cost minimization of the developer yields the unit cost function, which is equal to housing price under perfect competition. So we have:

$$P = (1-\rho)^{\rho-1}\, \rho^{-\rho} \cdot P_X^{R\,1-\rho} r^{\rho} \qquad (6)$$

A representative individual worker's base utility function if the worker is to provide 1 unit of effective labor is given by $U = h^{\beta} c^{1-\beta}$ with the budget constraint $w - Ph - c = 0$, where $h$ and $c$ are respectively the consumption of housing and the numeraire good $Y$. The corresponding indirect utility function is

$$V = wP^{-\beta} \qquad (7a)$$

From individual workers' maximization of utility we have $rK_R = \rho PH = \rho\beta wL$ and $\mathrm{P}_{\mathrm{X}}^{\mathrm{R}} X_{\mathrm{R}} = (1-\rho)PH = (1-\rho)\beta wL$. By substituting in for $w$ from (2) we have

$$K_R = \rho\beta\alpha_L^{\frac{1}{\alpha_L}} A^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} \left(\frac{1}{P_X^I}\frac{\alpha_X}{\alpha_L}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{1}{r}\frac{\alpha_K}{\alpha_L}\right)^{\frac{\alpha_K}{\alpha_L}} r^{-1} \qquad (8)$$

$$\mathrm{X_R} = (1-\rho)\beta\alpha_L^{\frac{1}{\alpha_L}} A^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} \left(\frac{1}{P_X^I}\frac{\alpha_X}{\alpha_L}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{1}{r}\frac{\alpha_K}{\alpha_L}\right)^{\frac{\alpha_K}{\alpha_L}} P_X^{R\,-1}. \qquad (9)$$

### 3.3 Public goods and the local government's objective function

The local government provides public goods such as road and telecommunication infrastructure, $G$, which raises the total factor productivity of industrial goods. . Specifically, in the production function of $Y$, TFP is determined by:

$$A = A'G^{\gamma}, \qquad (10)$$

where γ captures how effectively public goods can enhance the productivity of industrial production. *G* is produced one-for-one from the numeraire good, and its provision is financed by revenues from land sales, or in our static framework, rents on land. The government's budget constraint is thus given by

$$G = P_X^I X_I + P_X^R X_R. \qquad (11a)$$

By substituting into (11a) for $X_I$ and $X_R$ from (4) and (9), and substituting for $A$ from (10), we get

$$G = \left\{ [\alpha_X + (1-\rho)\beta\alpha_L] \left(\frac{\alpha_X}{P_X^I}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{\alpha_K}{r}\right)^{\frac{\alpha_K}{\alpha_L}} A'^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} \right\}^{\frac{\alpha_L}{\alpha_L-\gamma}}. \qquad (11b)$$

Note that we require $\alpha_L - \gamma > 0$ to ensure a well behaved equilibrium. From the literature, as we will see, $\gamma$ is quite small relative to $\alpha_L$.

For output $= \frac{wL}{\alpha_L}$, by substituting in for $w$ from (2), for $A$ from (10), and for $G$ from (11b) we have

$$Y = [\alpha_X + (1-\rho)\beta\alpha_L]^{\frac{\gamma}{\alpha_L-\gamma}} \left[ \left(\frac{\alpha_X}{P_X^I}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{\alpha_K}{r}\right)^{\frac{\alpha_K}{\alpha_L}} \left( A'^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} \right) \right]^{\frac{\alpha_L}{\alpha_L-\gamma}} \qquad (12)$$

Similarly, by substituting in for $w$, $P$, and then $A$ and $G$, we can re-write the indirect base utility in (7a) as

$$V = [\alpha_X + (1-\rho)\beta\alpha_L]^{\frac{\gamma}{\alpha_L-\gamma}} \cdot \alpha_L (1-\rho)^{\beta(1-\rho)} \rho^{\beta\rho} \left( A'^{\frac{1}{\alpha_L}} \alpha_X^{\frac{\alpha_X}{\alpha_L}} \alpha_K^{\frac{\alpha_K}{\alpha_L}} \right)^{\frac{\alpha_L}{\alpha_L-\gamma}} \cdot$$

$$L^{\frac{\epsilon+\gamma}{\alpha_L-\gamma}} P_X^{I\,-\frac{\alpha_X}{\alpha_L-\gamma}} r^{-\frac{\alpha_K}{\alpha_L-\gamma}-\beta\rho} P_X^{R\,-\beta(1-\rho)} \qquad (7b)$$

Note the output is declining in $P_X^I$ and $r$ while the base utility is declining in $P_X^I$, $P_X^R$ and $r$, as would be expected. And with scale economies both the output and the base utility are increasing

in effective labor, $L$.

As discussed previously, each local government maximizes an objective function, given certain weights to consumer welfare $(1-f)$ versus production $(f)$. The form of the objective function is $V^{1-f}Y^f$. Informed by the institutional backgrounds, we assume the local government's policy instrument is to choose differential prices for industrial versus residential land. Thus,

$$\max_{P_{X_I}^I,\, P_{X_R}^R} V^{1-f}Y^f,$$

$$\text{s.t. } X_I + X_R = \bar{X},$$

where $\bar{X}$ is the total amount of available land in city $i$. From (7b), (12) and (4) and (9) after substituting in for $A$ and then $G$ from (10) and (11b), all items are functions of $P_X^I$, $P_X^R$, $L$ and . When solving the constrained optimization problem, $L$ and $r$ as well as a set of parameters including $A'$ are taken as given. After factoring out and re-arranging items (see Appendix), we can solve for the optimal ratio

$$\frac{P_X^R}{P_X^I} = \frac{\alpha_L[(1-f)^{-1}-\beta(1-\rho)]}{\alpha_L+\alpha_X-\gamma}. \qquad (13)$$

Note because of the specific way of financing public goods, our model setup is a second best problem compared to the first best. Hence even if the political weight on output $f$ is 0; i.e., no distortion from trying to maximize GDP, we still won't have the optimal land price ratio given by (13) equal to 1, which would be a feature of the first best. For example if $f = 0$ and $\gamma \to 0$, $\mathrm{P_X^R} < P_X^I$ (noting then that the numerator [denominator] in (13) is less [greater] than $\alpha_L$). However for the parameters we shall use below, prices are close to being equal, with a ratio of 0.91 if $f = 0$. If $f = 1$, there will be a corner solution where the government would like to lower land for housing towards 0 and raise housing price towards infinity. Eqn. (13) has a quantity form where relative land usage from (4) and (9) is given by

$$\frac{X_R}{\mathrm{X_I}} = \frac{(1-\rho)\beta\alpha_L}{\alpha_X} \cdot \frac{\mathrm{P_X^I}}{\mathrm{P_X^R}} \qquad (14)$$

**3.4 Migration and the spatial allocation of population and effective labor**

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

$$U_{ni} = Z_i a_i V_i d_{ni}, \qquad (15)$$

where $Z_i$ denotes the amenity of living in city $i$; $V_i$ is the base utility of city i that depends on the effective wage rate and housing price of the city. Each worker in city i gets a random labor productivity draw $a_i$ from a Frechet distribution with cdf $\Psi_{\mathrm{i}}(x) = e^{-x^{-\theta}}$, where θ is the parameter that determines how dispersed the distribution is. The worker's effective labor supply is equal to $a_i$ and he earns $a_i w_i$ in total corresponding to a utility level of $a_i V_i$. And $d_{ni} \leq 1$ is the fraction of utility left-over net of migration costs, where we assume $d_{ii} = 1$ so that the stayers suffer no utility loss.

As is standard, the proportion of people moving from *n* to $i$ is

$$M_{\mathrm{ni}} = Prob(U_{ni} > \max\{U_{ns}, s \neq i\}) = \frac{(Z_i V_i d_{ni})^{\theta}}{\sum_s (Z_s V_s d_{ns})^{\theta}} \qquad (16)$$

For $N$ cities in the economy, the migration flow matrix determined by equation (16) imply that

$$\tilde{L}'_i = \sum_{\mathrm{n}\in\mathrm{N}} \frac{(Z_i V_i d_{ni})^{\theta}}{\sum_{k\in N}((Z_k V_k d_{nk})^{\theta})} \cdot \tilde{L}_n. \qquad (17)$$

This condition simply says that the allocation of population in the end is determined by the migration matrix and the original allocation of population. Note that $\tilde{L}_i$ is the population of city i in the initial year (which will be 2000 in our calibration), while $\tilde{L}'_i$ is the population of city $i$ in the ending year (which will be 2010 in our calibration). We assume the total population of the nation does not change over time (henceforth we normalize the total population in 2000 such that it is the same as 2010 in our calibration and counterfactuals), given growth of total population is not the focus of this paper. So

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

Apart from bodies, there is the allocation of effective labor. The total effective labor at city i is given by

$$\mathrm{L_i} = \sum_n E(a_i | moving\ from\ n\ to\ i) * \tilde{L}_n * M_{ni}.$$

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

$$\mathrm{E}(a_i | moving\ from\ n\ to\ i) = \left(\frac{1}{M_{ni}}\right)^{\frac{1}{\theta}} \cdot \Gamma(1 - \frac{1}{\theta}).$$

Here the average labor productivity conditional on moving from city n to city i is inversely related to the migration share. Intuitively, more people moving to the same city means that the productivity draws have to reach deeper into the distribution. Combining the above two conditions yields

$$L_i = \sum_n \tilde{L}_n \cdot M_{ni}^{1-\frac{1}{\theta}} \cdot \Gamma(1-\frac{1}{\theta}). \qquad (18)$$

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

### 3.5 Closing the model and calibration outline.

Given the actual capital cost for each city, we can solve for the spatial equilibrium of the model using equations (12), (7b), (13) and (14), in addition to two systems of equations defining the allocation of population and effective labor; that is, (17) and (18). Next, we describe the empirical work used in calibration strategy, apart from some parameter values we later take from the literature. We note we will be able to back out city-specific parameters from the equilibrium, such as $A', f, X$ and $Z$ utilizing estimated prices for capital, residential land and industrial land in each city, as well as migration costs from data. We can also recover the equilibrium quantities of endogenous variables in model units: $G_i, X_{Ii,}\, X_{Ri,}\, K_{Ii,}\, K_{Ri}$ .

## 4. Empirical work

We now turn to the empirical work where we estimate migration costs for China and the hedonic land prices by use type in each city. The prices of capital are taken from Chen, Henderson and Cai (2017), but discussed here.

### 4.1 Estimation of migration costs

There is a large literature on migration restrictions in China; and we note papers by Chan (2010), Au & Henderson ( 2006a, 2006b), Cai (2006), and Tombe and Zhu (2018). Early papers focused on formal migration restrictions. Post 2000, there are no longer formal migration restrictions in China. Instead the policy is to 'raise the doorsill' and make life unpleasant for migrants in cities (Cai, 2006, Lim et al (2012). But other factors such as the development of migration networks may be important. To see this we quantify migration costs.

In quantification, we do not assume symmetry in migration costs (Bryan and Morten, 2018), because in China provincial barriers to in-migration and the history of migration paths may differ

across provinces, so that the cost of moving from Beijing to Sichuan may differ than that for moving from Sichuan to Beijing (Tomba and Zhu, 2018). We focus on a formulation where there are asymmetric fixed costs of entering a province, but variable symmetric travel time costs, with a formulation initially inspired by Tombe and Zhu's (2018) analysis of asymmetric trade costs. Tombe and Zhu assert huge migration costs for China, mostly based on barriers for rural migrants moving across provincial boundaries to take urban jobs. Inter-provincial flows in China are low, which yields very high moving cost estimates in Tombe and Zhu. The implication is that people may be stuck in low productivity or undesirable places, which is a key efficiency and welfare issue.

We use a formulation of province to province migation costs, to correspnd to the data we have. We have 2010 data on province-to-province moves of people in the last 5 years; for the 10 year period flows we simply double this number. Based on the model below, we have 24*25 province origin destination pairs under which to estimate migration costs, we start with that and then show how we add in the prefecture to prefecture part.

The province to province migration share is given by $M_{ni} = \frac{(Z_i V_i d_{ni})^\theta}{\sum_s (Z_s V_s d_{ns})^\theta}$ in (16).[3] Taking logs for $M_{ni}$ and $M_{ii}$ and subtracting gives

$$ln\left(\frac{M_{ni}}{M_{ii}}\right) = \theta\, ln(d_{ni}) - ln\left(\sum_s (Z_s V_s d_{ns})^\theta\right) + ln\left(\sum_s (Z_s V_s d_{is})^\theta\right),$$

where we've assumed that $d_{ii} = 1$. Migration cost $d_{ni}$ is given by $d_{ni} = t_{ni} * \tilde{t}_i$, where $t_{ni}$ is variable, time- distance-based part of migration costs where $t_{ni} = t_{in}$ , and $\tilde{t}_i$ is a destination sunk cost, based on provincial barriers to entry. Substituting $d_{ni}$ leads to an econometric formulation as follows,

$$ln\left(\frac{M_{ni}}{M_{ii}}\right) = \theta\, ln(t_{ni}) + \theta\, ln(\tilde{t}_i) - ln\left(\sum_s (Z_s V_s d_{ns})^\theta\right) + ln\left(\sum_s (Z_s V_s d_{is})^\theta\right)$$
$$= \delta \cdot \text{dist}_{ni} + I_n + J_i. \qquad (19)$$

$I_n = \left[-\ln\left(\sum_s B_n W_s (Z_s V_s d_{ns})^\theta\right)\right]$ captures an origin fixed effect, and

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

$J_i = \left[ln\left(\sum_s B_i W_s (Z_s V_s d_{is})^{\theta}\right) + \theta\, ln(\tilde{t}_i)\right]$ captures a destination fixed effect.[4]

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

$$d_{ni} = \exp\left(\frac{\delta}{\theta} \cdot dist_{ni}\right) \cdot \exp\left(\frac{I_i + J_i}{\theta}\right)$$
$$= \exp\left(\frac{\delta}{\theta} \cdot dist_{ni} + \frac{I_i + J_i}{\theta}\right). \qquad (20)$$

By using data, we can estimate $\delta, I_i$ and $J_i$. Therefore, with assumed $\theta$, we are able to derive the easiness-to-access $d_{ni}$ for each migration pair (province-to-province). The distance measure is from based on work in Baum-Snow, Henderson, Turner, Zhang, and Brandt (2018), based on inferred driving times between locations over the 2010 road network, where speeds on major highways are set at 90kms/hr and on other roads at 25kms/hr. For the province to province times we average all the city pair distances between the two provinces.

**Figure 1: Destination Sunk Cost sorted by rank**

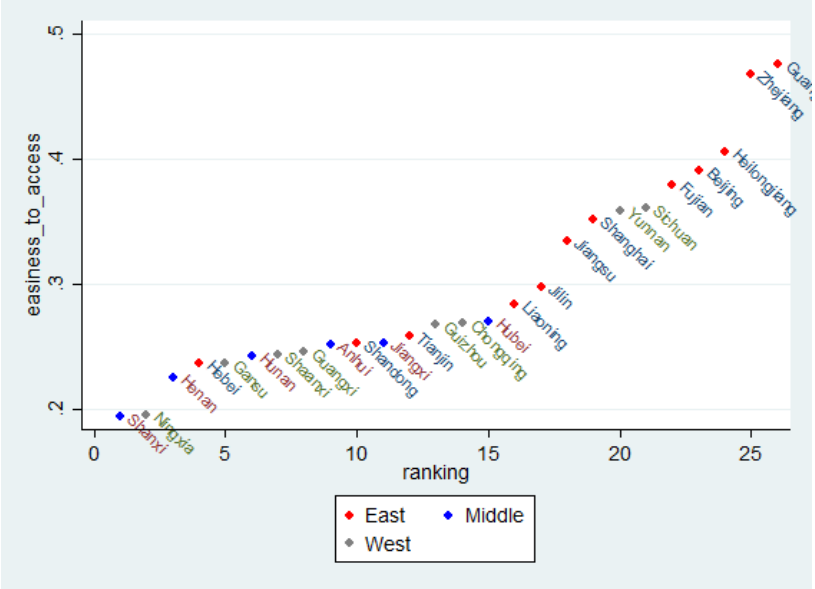



Figure 1 plots the relative fixed costs of entering a province. Note a higher value means lower costs, or more real income survives. Here the places with the lowest entry costs are Guangdong and Zhejiang provinces, but Beijing and Shanghai have also relatively low entry costs. The most difficult places to enter are Shanxi, Ningxia, and Henan. Beijing and Shanghai resist immigration by offering migrants poor living conditions with poor housing facilities in

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

migrant areas and poor access to state schools.[5] Yet they have relatively low fixed costs of entry as shown here based on huge inflows; the growth rate of migrants from outside the province in these cities in the 2000-2010 time period was 11-12% a year. The reality is that these cities have developed large long term migration networks, with many neighborhoods for example named after the origin of migrants there. These networks help migrants find housing and jobs and information on how to navigate the city and its regulations and restrictions. It is clear typical doorsill policies are not enough to offset the years of development of the networks and their benefits. While intending not to be, Beijing, in net, given its history of migration, is a welcoming place overall.

To derive city-level migration costs, for variable costs, we use the distance parameter from inter-provincial moves and the relevant distances. For fixed costs, for inter-provincial moves we continue to use the associated destination province fixed costs. For the fixed cost for intra-provincial moves, Tombe and Zhu (2018) argue that in general the costs of moving the same distance across provinces is twice within province moves. For the asymmeric case here, accordingly we simple double the $\phi_i$, correspondingly lowering intra-province migration costs. This assumes that the asymmetric cost pattern for within province moves mirrors the inter-provincial cost pattern across the heterogeneous provinces. Is this warranted? To investigate with available data, we know the extent of total within province moves in the years from 1995 to 2000. Low fractions of moves would suggest high barriers to internal movement. In Figure 2, we plot the fraction of within province moves against our estimated $\phi_i$, indicating the ease of entering a province. There is a strong positive, agruably proportional relationship, which motivates our choice.

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

**Figure 2. Within province flows and ease of entry**

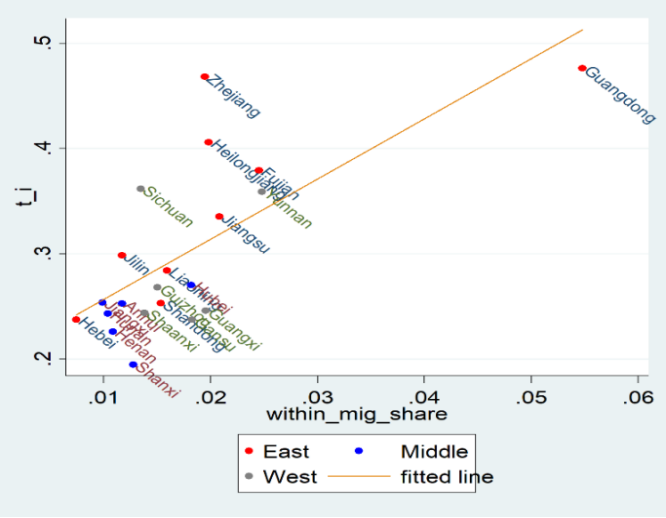



**Figure 3. City pairwise moving costs: fraction of utility left after moving**

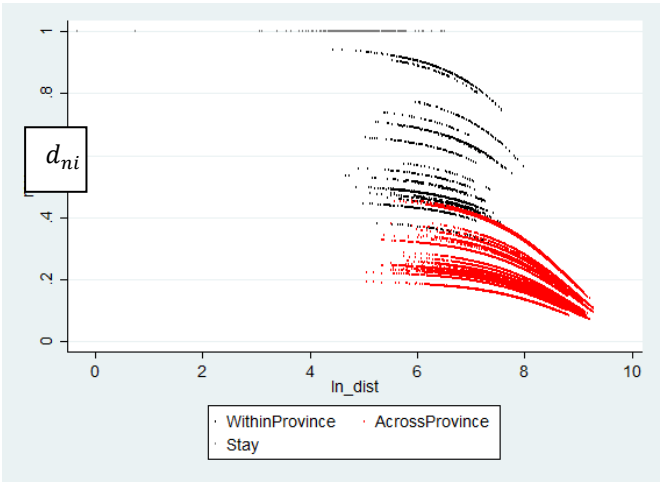



Figure 3 plots the moving costs of all city pairs, where a higher number is lower cost, with more utility left over. Under the formulation, all values are below 1. While there are within provinces moves where migration costs are low, for the vast majority it costs more than half of a person's real income to move. And given the high costs of inter-province migration relative to within province moves (by construction) , the vast majority of city pairs involving interprovincial moves leave only 5-40% of real income. These numbers on what real income is left after migration are actually higher than in Tombe and Zhu (2018). While one can quiblle over absolute magnitudes, for later counterfactuals they will give *relative* gains from changing

migration regimes, as well as impacts on city populations. [6]

### 4.2 Land allocation

For land allocation across use type we need land prices in every city in the residential versus industrial sector for the same quality piece of land. We utilize a large micro-level dataset that covers all the land transactions in Chinese cities from 2000-2015, including not only land parcels that are sold through public auction of land in China (most common for residential land transactions), but also those through negotiated sales (most common for industrial land transactions). It contains residential land, commercial land and industrial land transactions, where the category of commercial is a small fraction of transactions which we drop. It is by far the most comprehensive land transaction data of urban China. This dataset is obtained from the website http:// landchina.mlr.gov.cn where China's Ministry of Natural Resources posts timely land transaction information to the public.

For this paper to establish equilibrium prices for 2010 with sufficient sample by use in each city, we use the data for the years 2010-2012 to run hedonic regressions, in order to compare prices for equal quality land in different cities in different uses. There are 136,351 industrial land transactions and 94,380 residential land transactions, covering 331 cities nationwide. With three years pooled together, almost all cities have more than 30 land transactions and a majority of them have more than 50 transactions, for each of residential land and industrial land.

For the hedonics, the information on each land parcel transacted includes the sale price, land area, regulatory maximum floor-to-area ratio, land use type, land quality tier, transaction format, transaction date, buyer, and address. We also control for distance to the city center and distance to the center of the district the plot is in, allowing for importance of city sub-centers.[7]

[6] To fully deal with migration, we would need a dynamic framework with micro data (e.g., Kennan and Walker 2011) where we compare moving costs for people of different ages who have present values of income differentials over different time horizons. We don't have such data for China and this iw well beyond the scope of this paper.

[7] The distances to both the city center and the district center for each land parcel are provided by Tian, Wang and Zhang (2018) who use the surrounding streets of each parcel according to its address to establish the boundaries of the parcel. They then find the smallest polygon that contains the land parcel on Baidu Map (www.map.baidu.com). The geographic coordinates of the polygon's centroid are used as the coordinates of the parcel. Using the coordinates, they calculate the distances to both the city center and the district center for each parcel.

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We first construct the hedonic land price by city for residential land and industrial land, by running hedonic regressions city by city for each type of land separately. Let superscript *cj* denote city *c* and land use type *j* where $\mathrm{j} \in \{\mathrm{residential}, \mathrm{industrial}\}$. And let subscript *it* denote land parcel *i* sold at year *t*. The hedonic regression is specified as follows:

$$\log\left(price_{it}^{cj}\right) = \mathrm{b}_0^{\mathrm{cj}} + \beta^{cj} R_{\mathrm{i}} + I_t^{cj} + \epsilon_{it}^{cj} \qquad (21)$$

In the above equation, *price* is the unit sale price of the land parcel, is a vector of parcel characteristics note above[8] , and $I_t$ is the transaction year fixed effect.

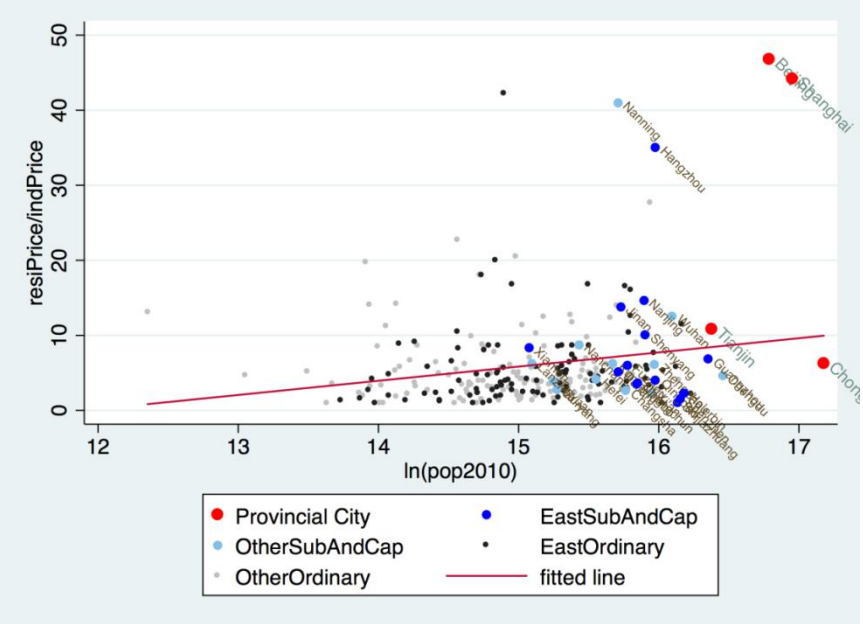
For each city we save the estimated coefficient vector denoted as $\Omega^{\mathrm{cj}}$ for two types of land uses. We then predict the hedonic land price for city *c* and land type *j* using $\Omega^{\mathrm{cj}}$ and the same set of characteristics of some national proto land parcel, according to the above hedonic regression equation. The characteristics of the proto land parcel are chosen as follows: for land area and floor to area limits, we use the medians of the combined residential land and industrial land sample. We set land quality tier to the most populated in the combined sample and the same for auction format. Both the distance to city center and the distance to district center are set to be 2km. Finally, the year is chosen to be 2010. This then gives us our data for a nationally representative piece of land city by city by type.

In Figure 4, we plot the relative price of residential to industrial land. The ratios are very high in general even for the same quality land, with a median of 4.1 across all cities. Cities like Beijing and Shanghai which are a testing ground for future national leaders who will be tasked

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

with growing the economy are very high. This reflects the extraordinarily high house prices in such cities, which are driven by supply restrictions favoring industrial use.

**Figure 4 Relative price ratio of residential land over industrial land**




### 4.3 Capital costs

Banks in China today remain de facto state owned. There have been extensive reforms over the last 20 years designed to put banks more on a market basis and to try to reduce the extent of non-performing loans. However, the Committee of the Chinese Communist Party retains the power to appoint the boards of directors and senior management of banks and offer directives. The state's interest is beyond the efficient allocation of capital and includes vague criteria such as “stability”, “lawfulness”, and national “macroeconomic measures”. Individuals appointed to bank senior management posts are personnel with standing in the Communist Party hierarchy (Howson, 2010) 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 and Singhe (1999), Au and Henderson (2006b), Dollar and Wei (2007) and Chen, Henderson and Cai (2017).

Less well known and of focus here in spatial bias. Liu (2007) notes that while bank lending is concentrated on China's state-owned enterprises, it is also concentrated on major cities, which supposedly lead national economic growth. Commercial banks in China have cautiously

retrenched credit-extending authority from their local branches (Liu, 2007), so that below the provincial level, they have limited autonomy to extend credit to new clients and investment projects. Branches in cities are allocated funds for loans with stated priorities, and such allocations may reflect the political influence and connections of local leaders to provincial and national leaders, as they attempt to garner credit for enterprises in their cities. Chen et al (2017) argue that there is a lot of variation in local practices both in interest rate manipulation and charges and in default provisions.[9]

Using the Annual Survey of Medium and Large Industrial firms for 1998-2007 accounting for 95% of industrial sales in China, Chen et al (2017) estimate a traditional average revenue product [ARP] equation to quantify specific differentials in the price of capital faced by firms under different circumstances, just as in Song and Wu (2013) and Dollar and Wei (2007). Like Dollar and Wei (2007), Chen et al find that SOE's have deep discounts on the price of capital and that some provincial level cities and East coast cities also have strong discounts of up to 30% or more for private firms, with strong year-by-year persistence in the price of capital for cities. Using their data from Annual Survey of Medium and Large Industrial Enterprises for 2006-2007, we simply and estimate a single price of capital facing each city. The ARP equation for firm *s* in industry *j* in location *i*, derived from profit maximization is

$$\ln\left(\frac{p_{ji}^{*}y_s}{k_s}\right) = \ln(r_i) - \ln\left(1 - \frac{1}{\eta_{ji}}\right) - \ln\alpha_{Kj} + \epsilon_{ijs} \quad (22)$$

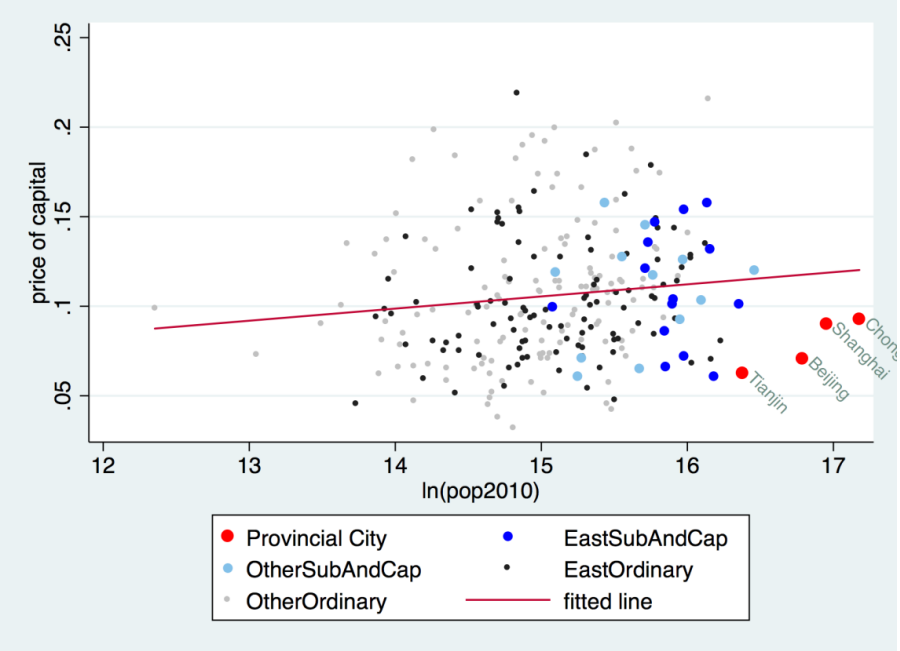
$p_{ji}^{*}$ is the output price to the firm net of VA taxes and depends on industry and local competition. $y_s$ and $k_s$ are output and input of capital. $r_i$ is the price of capital specific to city *i* , identified by city fixed effects. The $\alpha_{Kj}$ are industry fixed effects, capturing differences in capital intensity. $\eta_{ji}$ are local demand elasticities represented by controls for the 1995 number of firms in an industry in a prefecture and for measures of overall market access, in particular distance to the coast and 1990 GDP within 150 kms of the prefecture city center. The city price term reflects the combined influences of cities having greater shares of more favored SOE's and having more favored allocations for private firms. The city-specific price of capital is from firm level data pooled for 2006 and 2007 (with a time fixed effect added in).

The resulting prices of capital normalized to average about 0.10 are shown in Figure 4.

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

Note three things. First the price of capital rises with city size, which captures in part the fact that smaller and typically more remote cities such as in the north still have a high representation of SOE's with their low prices. Second the four provincial level cities face very low prices. Finally, there is the wide dispersion in prices, a key issue in the original Hsieh and Klenow (2007) paper.

**Figure 5. City prices of capital**




## 5. Calibration results

We now turn to calibrating the model and then evaluating the parameters it yields. Details of the calibration steps are in the Appendix. We will assume some parameter values from the literature as listed in Table 1. Given those parameters, in addition to value added in production (or Y) for each the city which is recorded as city "GDP" for 2010, estimated prices for capital, residential land and industrial land in each city, migration costs and beginning (2000) and final population (2010) for each city, we can recover the other city-specific parameters as well as the equilibrium quantities of some endogenous variables of the model. These are $A'$, $G$, $f$, $X_{Ii,}$ $X_{Ri,}$ $K_{Ii,}$ $K_{Ri}$, and $Z$, where $A'$ comes from (12) and then $G$ from (11b); $f$ comes from eqn. (13); $X_{Ii,}$ $X_{Ri,}$ $K_{Ii,}$ and $K_{Ri}$ come from eqns. (4), (9), (3) and (8) using eqn. (10). These then give $\bar{K} = \sum_{i \in N} (K_{Ri} + K_{Ii})$ and $\bar{X}_i = X_{Ri} + X_{Ii}$ which will give us the total national capital stock and total land per city. Finally $Z$

comes from solving the system of equations in (17), after substituting in for estimated migration costs, beginning and final population in each city, and $V$ in (7b). We note that we use population numbers; we do not have labor force for 2010 and migration numbers are population based.

**Table 1: Parameters**

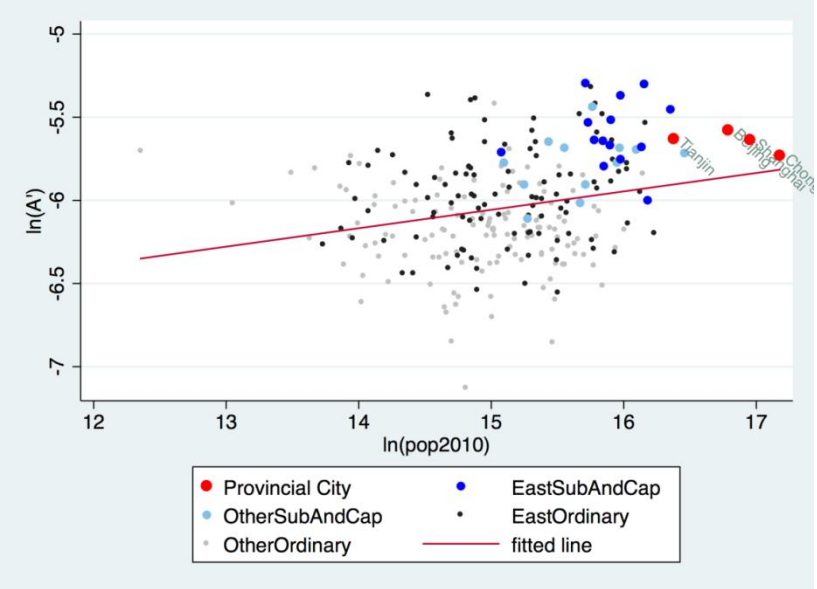
| Name | Value | Notes | Source |
|---|---|---|---|
| $\beta$ | 0.26 | Housing spending share | Cao, Chen and Zhao (2018) |
| $\rho$ | 0.7 | Capital share, housing production | Tan, Wang and Zhang (2018) |
| $\alpha_L$ | 0.55 | Labor share, Y production | C-E Bai and Z. Qian (2010) |
| $\alpha_X$ | 0.07 | Land share, Y | A. Valentinyi and B. Herrendorf (2008). Increases their share for the USA of 0.05 of land in capital income to reflect China's greater capital share on production |
| $\alpha_K$ | 0.38 | Capital share, Y | Back out from $\alpha_L + \alpha_K + \alpha_X = 1$ |
| $\gamma$ | 0.06 | Government investment productivity | Melo et al (2013 RSUE)'s meta study. 0.06 is the mean over all studies and countries. Non US countries and long run studies tend to average modestly higher $\gamma$ 's. Wu Feng and Wang (2017) in unpublished work estimate 0.016 for China. |
| $\epsilon$ | 0.04 | Degree of agglomeration economies | Typical estimate cited in Rosenthal and Strange (2004) and consistent with recent work by de la Roca and Puga (2017) |
| $\theta$ | 4.0 | Dispersion parameter, Frechet | The number is based on Bryan and Morten (2018), although higher than their 3.2. |

The focus in this subsection is on evaluating our estimates of $A'$, $G$, $f$, and $Z$.

**5.1 Productivity**

We start with $A'$, the productivity parameter. Figure 6 show the positive relationship between city size and $A'$. However, note that East political cities and political cities in general tend to have higher $A'$, perhaps because they are favored with better technology. To explore the relationships we present some regressions in Table 2.

## Figure 6. Productivity




## Table 2: Productivity Parameters (lnA')

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Share workers 19-55 with college,2000 | 2.993*** | 2.328*** | 2.104*** | 1.766*** | 1.769*** |
| | (0.315) | (0.380) | (0.337) | (0.402) | (0.404) |
| Ln rainfall | 0.0158 | -0.0184 | 0.0279 | 0.0118 | 0.0127 |
| | (0.0598) | (0.0582) | (0.0654) | (0.0655) | (0.0661) |
| Ln distance to nearest port | -0.0885*** | -0.0423** | -0.0384** | -0.0241 | -0.0242 |
| | (0.0136) | (0.0169) | (0.0149) | (0.0166) | (0.0167) |
| Avg, temp winter | 0.00330 | 0.00588** | 0.00178 | 0.00358 | 0.00354 |
| | (0.00243) | (0.00248) | (0.00245) | (0.00265) | (0.00268) |
| west | | -0.197*** | | -0.109* | -0.109* |
| | | (0.0533) | | (0.0613) | (0.0615) |
| middle | | -0.159*** | | -0.0763 | -0.0766 |
| | | (0.0422) | | (0.0466) | (0.0468) |
| Province city | | 0.190 | | 0.132 | 0.128 |
| | | (0.145) | | (0.139) | (0.145) |
| Sub and provincial capital | | 0.201*** | | 0.148** | 0.147** |
| | | (0.0682) | | (0.0683) | (0.0698) |
| Ln pop 2000 | | | | | 0.00346 |
| | | | | | (0.0328) |
| Ln Total FDI investment 1996 | | | 0.0587*** | 0.0436*** | 0.0432*** |
| | | | (0.0109) | (0.0124) | (0.0130) |
| Constant | -5.634*** | -5.582*** | -6.365*** | -6.168*** | -6.220*** |
| | (0.294) | (0.285) | (0.336) | (0.344) | (0.604) |
| Observations | 265 | 265 | 213 | 213 | 213 |
| R-squared | 0.418 | 0.469 | 0.438 | 0.456 | 0.456 |

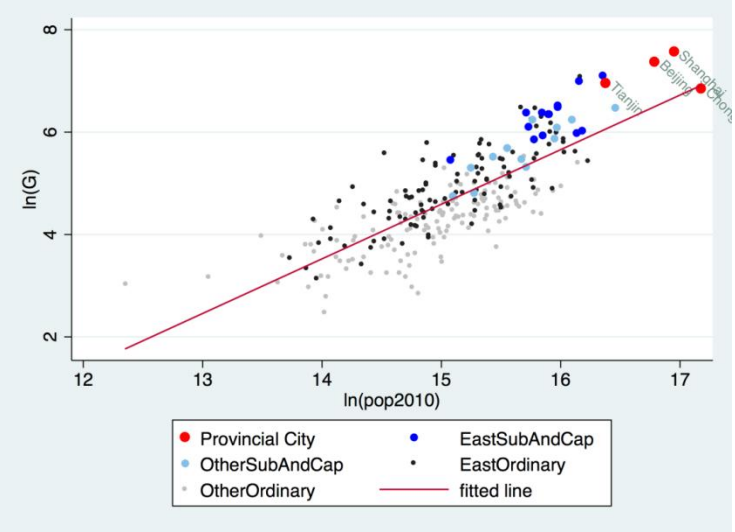
Standard errors in parentheses $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Five things stand out from the regressions. First is that, given we don't model transport costs of commodities, $A'$captures access to the coast. Second given we treat labor as homogeneous except for a productivity draw, $A'$ captures higher labor force quality measured by fraction of workers age 19-55 with college education in 2000. Third high FDI investments in the early years are correlated with high productivity. Fourth, cities in the East and political cities in particular have higher $A'$, even after accounting for distance and labor force quality. Finally once these factors are controlled for the correlation with city population goes to zero. All these accord with our expectations as to correlates of $A'$.

**5.2 Government infrastructure spending**

From our model calibration, we obtain local government spending $G$ in Figure 7, which rises with city size and is higher in political cities. We also have the city-level data on: (1) average annual local spending on infrastructure over 2008-2011[10] and (2) average annual city government's land sale revenue over the same period. The top panel of Table 3 shows simple correlation coefficients between the calibrated G and these two city-level variables. They are highly correlated. The bottom panel shows that to a very large some degree these correlations persist after factoring out population scale for each variable and looking at the correlations of the residuals. Clearly the model is fitting, after factoring out prefecture scale.

**Figure 7 Government expenditure G**




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

**Table 3 Correlations**

| Correlation Matrix | | | |
|---|---|---|---|
| | Ln Avg. Invest. | Ln(G, model) | Ln Avg. Land Revenue |
| Ln Avg. Invest. | 1.0000 | | |
| Ln(G, model) | 0.7660 | 1.0000 | |
| Ln Avg. Land Revenue | 0.7688 | 0.8299 | 1.0000 |
| Correlation Matrix (after factoring out ln pop size out) | | | |
| | Ln Avg. Invest. | Ln(G, model) | Ln Avg. Land Revenue |
| Ln Avg. Invest. | 1.0000 | | |
| Ln(G, model) | 0.6537 | 1.0000 | |
| Ln Avg. Land Revenue | 0.6527 | 0.6838 | 1.0000 |

Ln Avg. Invest.: Annual average (2008-2011) local investment in infrastructure;
Ln Avg Land Revenue: Annual average (2008-2011) local government's total land revenues;

### 5.3 Bias in political local system towards raising GDP: Measured by f

From differential residential versus industrial land prices we can back out estimates of *f* for each city. Figure 8 plots these estimates. They average 0.710 with a median of 0.764. Many are over 0.8 and they are especially high for some political cities, presumably assigned to rising ambitious political leaders. Of course there are more "enlightened" places which appear to value the welfare of residents, such as Shenzhen (the 2nd lowest dark blue dot). We also report regressions in Table 4. $f$ is a political variable, that is only related to a few key covariates. It is not related to many city characteristics, such as education and size. However it is lower in more agricultural places where industry and its growth is less of a focus. Second, cities in the East region have lower *f*'s, indicating a stronger push in the East for considering consumer welfare. The key political variable on which we have data is the age of the local leader, the Party Secretary (averaged over 2000-2010). In Wang, Zhang and Zhou (2018), local leaders are on a path to promotion, where promotion depends heavily on economic achievement measured by local GDP. Maximizing GDP involves effort to manipulate constraints imposed by the center and placate local citizens. Older leaders have a glass ceiling based on mandatory retirement ages and promotion is unlikely, so they exert less effort. Very young leaders are not at a critical stage yet, or may be more reform minded in 2010, having the welfare of local residents more in mind. Wang, Zhang and Zhou (2018) find that that effort to be promoted is maximized about age 50. In Table 4, remarkably, that is also the inflection point for age in terms of a maximal $f$.

**Figure 4 Political bias towards raising GDP: f**

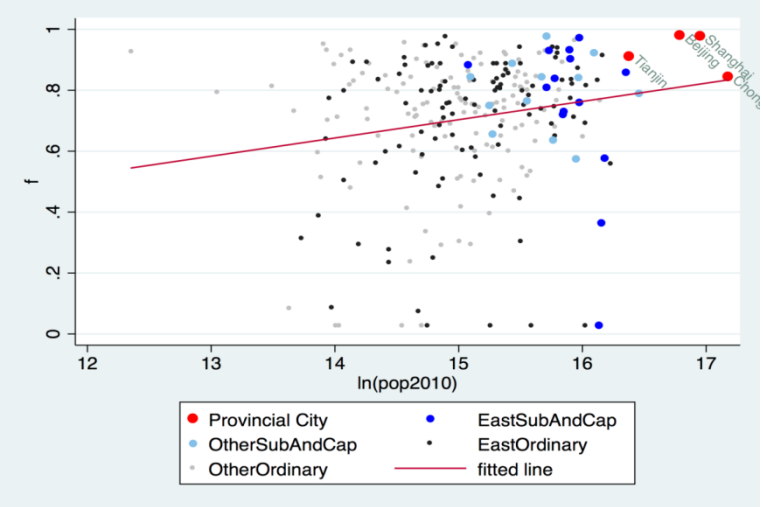



**Table 4. Correlates with f, the weight on GDP in leaders' preferences**

| | (1) | (2) | (3) |
|---|---|---|---|
| Share workers 19-55 with college | 0.143 | 0.160 | -0.0835 |
| | (0.230) | (0.237) | (0.287) |
| Share employ in manufacturing | 0.0916 | 0.112 | 0.179 |
| | (0.109) | (0.111) | (0.122) |
| Share employ in agriculture | -0.892*** | -0.889*** | -0.648** |
| | (0.257) | (0.256) | (0.277) |
| Ln distance to nearest port | -0.0197* | -0.0198 | -0.0220 |
| | (0.0114) | (0.0129) | (0.0142) |
| Party secretary age | | 0.450** | 0.518*** |
| | | (0.183) | (0.186) |
| PS age^2 | | -0.00450** | -0.00519*** |
| | | (0.00184) | (0.00186) |
| Ln pop 2000 | | | 0.0208 |
| | | | (0.0226) |
| east | | | -0.0805** |
| | | | (0.0348) |
| west | | | -0.0532 |
| | | | (0.0392) |
| Sub and provincial capital | | | 0.0676 |
| | | | (0.0567) |
| cons | 0.786*** | -10.43** | -12.18*** |
| | (0.0989) | (4.557) | (4.615) |
| *N* | 265 | 261 | 261 |
| *R-square* | 0.084 | 0.099 | 0.129 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Share employment in manufacturing is the share of manufacturing in total non-agricultural employment in 2008; share of employment in agricultural is the share in total employment in 2008; party secretary age is the weighted average of party secretaries' starting ages in each city between 2000 and 2010. The party secretary data do not apply to the 4 provincial level cities, so we do not report on them.

## 5.4 Consumer amenities, Z

**Figure 9. Consumer amenities**

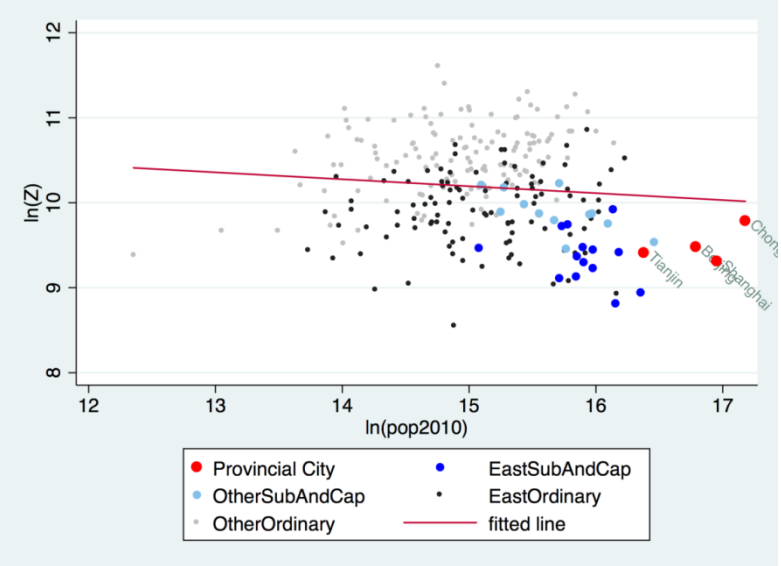



**Table 5. Correlates with consumer amenities (lnZ)**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Avg, temp winter | 0.00850* | 0.00725* | 0.00491 | -0.00840** | -0.00786** |
| | (0.00449) | (0.00438) | (0.00434) | (0.00394) | (0.00393) |
| Ln rainfall | -0.0487 | -0.113 | -0.130 | -0.0761 | -0.0591 |
| | (0.110) | (0.108) | (0.106) | (0.0888) | (0.0889) |
| Ln distance to nearest port | 0.145*** | 0.129*** | 0.147*** | 0.0408* | 0.0359 |
| | (0.0232) | (0.0230) | (0.0232) | (0.0230) | (0.0243) |
| Ln PM 2.5 | -0.0130 | -0.0155 | -0.0678 | -0.0222 | -0.0245 |
| | (0.0622) | (0.0605) | (0.0612) | (0.0529) | (0.0527) |
| Ln commuting time | -1.006*** | -0.664*** | -0.698*** | -0.952*** | -0.860*** |
| | (0.178) | (0.197) | (0.192) | (0.167) | (0.178) |
| Share workers 19-55 with college | | -2.354*** | -2.709*** | -2.520*** | -2.055*** |
| | | (0.640) | (0.635) | (0.550) | (0.604) |
| Ln pop 2000 | | | 0.164*** | 0.195*** | 0.209*** |
| | | | (0.0496) | (0.0420) | (0.0431) |
| West | | | | -0.0742 | -0.0482 |
| | | | | (0.0757) | (0.0773) |
| East | | | | -0.610*** | -0.608*** |
| | | | | (0.0648) | (0.0646) |
| Provincial city | | | | | -0.0243 |
| | | | | | (0.248) |
| Sub and provincial capital | | | | | -0.193* |
| | | | | | (0.104) |
| Constant | 12.82*** | 12.40*** | 10.25*** | 10.99*** | 10.41*** |
| | (0.797) | (0.783) | (1.004) | (0.847) | (0.916) |
| Observations | 222 | 222 | 222 | 222 | 222 |
| R-squared | 0.304 | 0.345 | 0.377 | 0.568 | 0.576 |

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Last there are consumer amenities. Figure 9 shows a decline with city size: potentially a congestion and pollution issue. Table 5 shows some correlations, where we focus on columns 3 and 5. The neat result is that once we control for commuting times which is a strong disamenity, population becomes an amenity, where bigger denser cities provide more consumption amenities and also social interaction opportunities ("consumer cities" as in Glaeser, Kolko and Saiz, 2001). But other items like education of the population and being near a coastal port are disamenities, unlike for production. East coast cities and political cites in both the figure and table, with their rapid growth and in-migration do badly. Weather and pollution variable have an inconsistent or weak impact.

**Other measures**

There are other equilibrium outcomes which can be backed out of the model, such as housing prices and built area of the city, as well as calibrating wages per effective unit of labor or base utility. In the Appendix, graphs show that actual housing prices from China's Regional Statistic Yearbooks correlate well with model ones, as do land areas. And effective wages rise with city size, an expected scale effect.

## 6. Counterfactuals

For counterfactuals we are primarily interested in two experiments. What happens if we remove capital market favoritism, so the endogenous price of capital is equalized across cities? Second what happens if, in addition, we set all weights on GDP in the local political process to zero, which will alter the allocation of land within each city more towards residential use. In general, we will focus on this second counterfactual. We also look at an experiment which lowers migration costs for high migration costs areas.

To do the second counterfactual, we need to solve for the return on capital which equates the sum of local capital demands to the given national supply, the local prices of residential and industrial land which clear each local land market at the given supply, and the migration flows and new city populations which clear the national labor market. Apart from seeing the new allocations, we also need a welfare measure. Total national welfare, as is conventional, is expressed as[11]

[11] It is also possible to derive expressions to calculate average welfare and inequality based on where people end up.

$$\mathrm{W} = \sum_{\mathrm{i}=1}^{\mathrm{N}} \frac{\tilde{L}_i}{\sum_{j=1}^{N} \tilde{L}_j} \cdot \gamma \left[ \sum_{k \in N} (Z_k V_k d_{ik})^{\theta} \right]^{\frac{1}{\theta}}, \qquad (23)$$

where $\gamma = \Gamma(\frac{\theta - 1}{\theta})$ , from the gamma function (Tombe and Zhu, 2018). Note that the expected utility of all people originating from city i (before migration) is $\mathrm{E}[\mathrm{U_i}] = \gamma \left[ \sum_{k \in N} (Z_k V_k d_{ik})^{\theta} \right]^{\frac{1}{\theta}}$. Relative inequality (weighted by the initial population) is thus measured by

$$\text{Inequality}_{\mathrm{o}} = \sum_{\mathrm{i}}^{\mathrm{N}} \frac{\tilde{L}_i}{\sum_{j=1}^{N} \tilde{L}_j} \cdot (\mathrm{E}[\mathrm{U_k}]/\mathrm{W} - 1)^2 \quad (24)$$

We now turn to the counterfactuals. Table 6 summarizes the aggregate changes which we will discuss in turn.

**Table 6. a. Aggregate outcomes: Counterfactuals versus benchmark**

| | Aggregate output | Social welfare | Real return on capital | Aggregate capital income | Inequality |
|---|---|---|---|---|---|
| Benchmark, equilibrium | 6242.8 | 1.622 | n.a. | 199,311 | 0.00684 |
| Counterfactual 1: Equalize price of capital, r | 6962.5 | 1.694 | 0.108 | 222,288 | 0.0332 |
| Counterfactual 2: Equal r & local govt max represetative residenrt welfare | 6808.4 | 1.839 | 0.106 | 217,370 | 0.0332 |
| Counterfactual 3 : Counterfactual 2 & lower entry costs for high cost places | 7178.4 | [2.004] | 0.112 | 229,181 | 0.0327 |

**Table 6. b. Example city populations**

| | Benchmark | Counterfactual 1 | Counterfactual 2 | Counterfactual 3 |
|---|---|---|---|---|
| Beijing | 19.61m | 10.37m | 14.06m | 8.97m |
| Shanghai | 23.02m | 17.46m | 21.89m | 16.75m |
| Shenzhen | 10.35m | 15.35m | 12.66m | 10.08m |

With the Frechet distribution, $\mathrm{E}[\mathrm{U_i}] = \mathrm{E}[\mathrm{U_i}|moving\ to\ city\ k]$, for any destination city k. Therefore, the average welfare of people currently living in city k (after migration) is given by$\mathrm{E}[\widetilde{U}_{\mathrm{k}}] = \sum_{\mathrm{i} \in \mathrm{N}} \frac{\tilde{L}'_{ik}}{\tilde{L}'_k} \mathrm{E}[\mathrm{U_i}|moving\ to\ city\ k] = \sum_{\mathrm{i} \in \mathrm{N}} \frac{\tilde{L}'_{ik}}{\tilde{L}'_k} \cdot \gamma \left[ \sum_{s \in N} (Z_s V_s d_{is})^{\theta} \right]^{\frac{1}{\theta}} \cdot$ Thereby we can also define another measure of inequality using $\mathrm{E}[\widetilde{U}_{\mathrm{k}}]$,$\text{Inequality}_{\mathrm{d}} = \sum_{\mathrm{k}}^{\mathrm{N}} \frac{\tilde{L}'_k}{\sum_{j=1}^{N} \tilde{L}'_j} \cdot \left(\mathrm{E}[\widetilde{U}_{\mathrm{k}}]/\mathrm{W} - 1\right)^2$

### 6.1 Counterfactual 1: Equalizing the price of capital

We can solve the equilibrium for an equalized price of capital, removing the capital market bias towards certain political and other cities. The local government's objective function remains unchanged, which implies that the allocation of residential and commercial land is fixed in each city given the same land supply. The *relative* price of one type of land to the other is thus also left unchanged. However, because capital market prices and populations will change so will the absolute level of land prices and housing prices, generally moving up or down as population of a city increases or decreases. For this counterfactual we show the aggregate national changes, city-by-city population changes, and changes of welfare of people by origin city.

Equalizing the price of capital brings broad efficiency gains relative to the benchmark (the current 2010 equilibrium), raising aggregate output and returns to capital by about 11.5% each and improving worker welfare by 4.4% overall. The main impact is to lower the population of favored places like Beijing and Shanghai, as well as the welfare of people born there, and raise populations and welfare in cities that were discriminated against. Results are shown in figures 10 and 11. Highly favored cities like Beijing and Shanghai lose enormous population: Beijing by 47% and Shanghai by 24%, while heavily discriminated against cities like Shenzhen (Chen, Henderson and Cai, 2017) see 48% population increases. Items like output, government spending, and absolute land prices basically move with population. Housing prices are little affected: in the cities where the price of capital rises, population and land prices fall. We will present more details for counterfactual 2**.**

A key issue is that national inequality rises. Why? Some cities with older heavy industries (SOE's) and low capital returns are in lower welfare and higher 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. The Appendix offers some details. So inequality rises nationally. Put another way, current capital subsidies in some cities forestall the wage and employment losses which would result if these heavy industry cities had to compete on a level playing field.

In summary, capital market biases have profound city population effects and also large overall welfare effects. Capital owners stand to gain the most, but a 4.4% increase in worker welfare is large for these type of counterfactuals. And the welfare effects are highly varied across locations, with distinct winners and losers, raising spatial inequality.

**Figure 10. Population under counterfactual 1 vs benchmark**

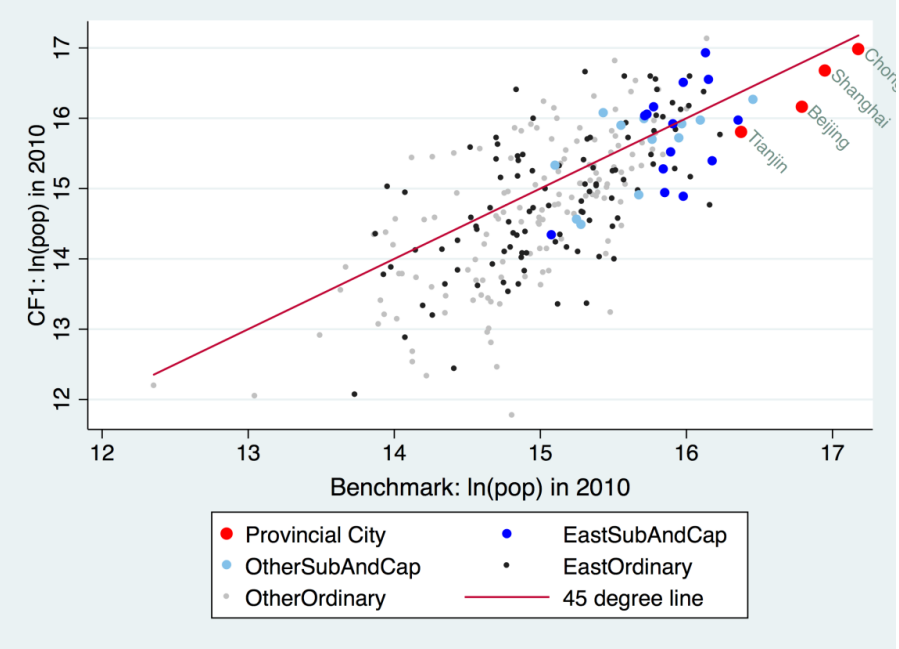
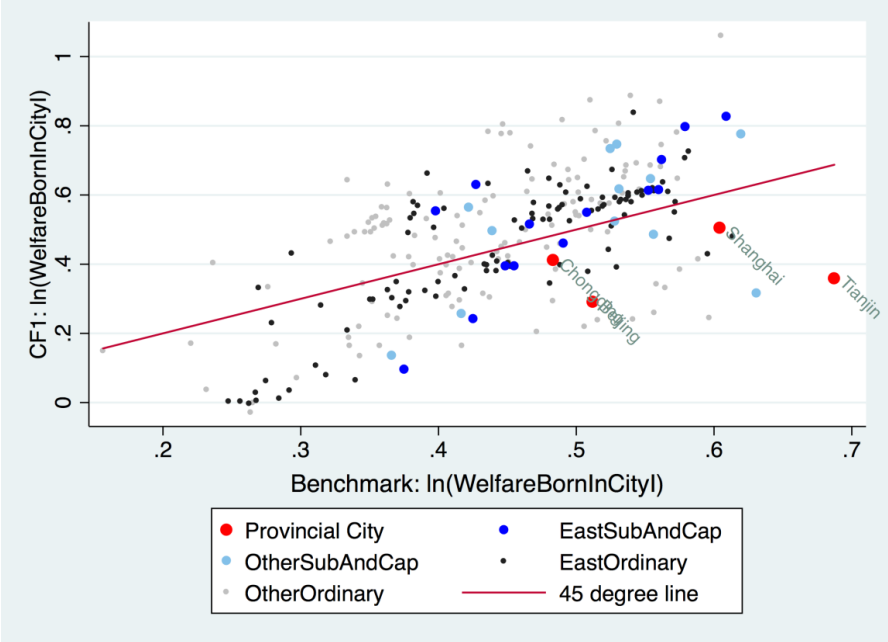



**Figure 11. Welfare for those born in a city under counterfactual 1 vs benchmark**




## 6.2 Counterfactual 2: Equalizing the price of capital & local governments seek to maximize welfare of the representative worker

In Counterfactual 2, in addition to freeing up capital markets, we have local governments

each place a weight of 1 on local representative consumer welfare and no weight on maximizing output per se in allocating land between residential and industrial use. The result is to almost equalize the price of land between residential and industrial use (a counterfactual we also did but for which the results are essentially the same as for this counterfactual).

Overall, focusing on local consumer welfare results in more land going to consumers and lower housing prices compared to the benchmark, but higher industrial land prices. Consumer welfare national now rises much more over counterfactual 1 (which raised welfare by 4.4%) to 13% above the benchmark, while national output and capital income decline modestly relative to counterfactual 1, but are still 9% higher than the benchmark. These are enormous efficiency gains. Populations in cities like Beijing and Shanghai still fall relative to the benchmark but are higher than in counterfactual 1. Having these cities focus more on consumer welfare in allocating land for residential use brings back population relative to counterfactual 1, but Beijing's population still remains 28% lower than in the benchmark, or current equilibrium. Losing its capital market favoritism hurts Beijing; Shanghai starts less favored in capital markets and has a bigger move to focusing on consumer welfare, so in the end its population only falls by 5%

Figure 12 shows population relative to the benchmark and government spending and output generally follow the same pattern. Government spending and output rise and fall with population changes although there are secondary impacts. The efficiency gains come from a reorientation away from trying to provide infrastructure to increase recorded output. We show the impacts on infrastructure in Figure 13. Note the huge declines even relative to population for cities like Beijing and Tianjin, as well as Shanghai, with the change away from a political focus on output.

Figure 14 shows the pretty much universal decline in housing prices, which is accompanied by a universal increase in residential land allocations (not shown). The large press and government discussion of high 'unaffordable' housing prices in many Chinese cities is closely related to policies restricting residential land allocations, the most basic driver. Figure 15 shows the complexity of general equilibrium effects. While industrial land allocations fall in all cities (to mirror a rise in residential), the impact on industrial land prices also depends on demand, which is based on population changes and output changes which reflect both population and efficiency gains. Industrial land prices rise in many cities. Not

shown, while the use of residential land rises in all cities, the use of residential capital shows a mixed pattern again driven by general equilibrium demand effects.

**Figure 12. Counterfactual 2: Populations**

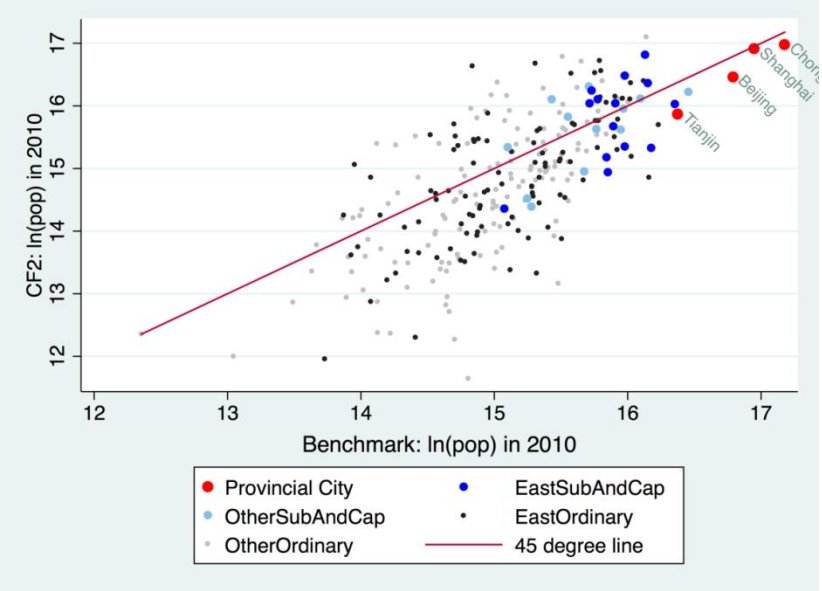



**Figure l3. Counterfactual 2: Infrastructure investment**

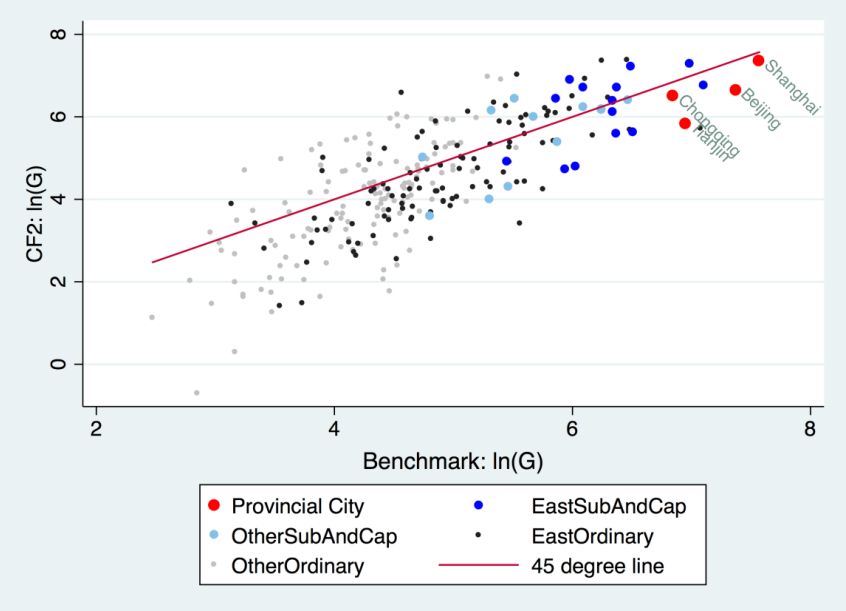


**Figure 14. Counterfactual 2: Housing prices**

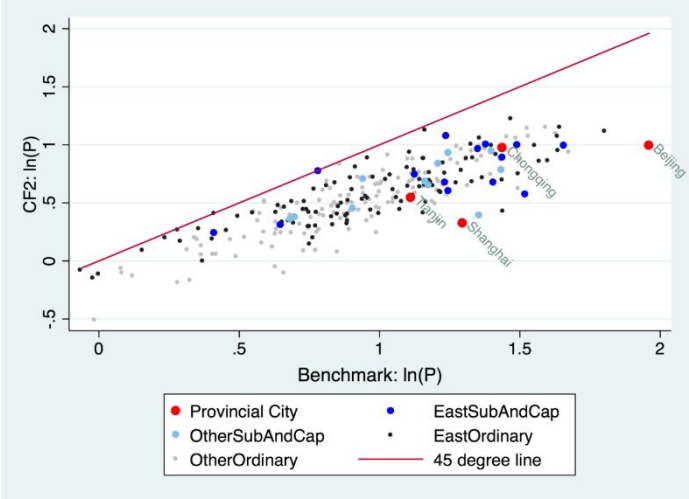



**Figure 15. Counterfactual 2: Prices of industrial land**

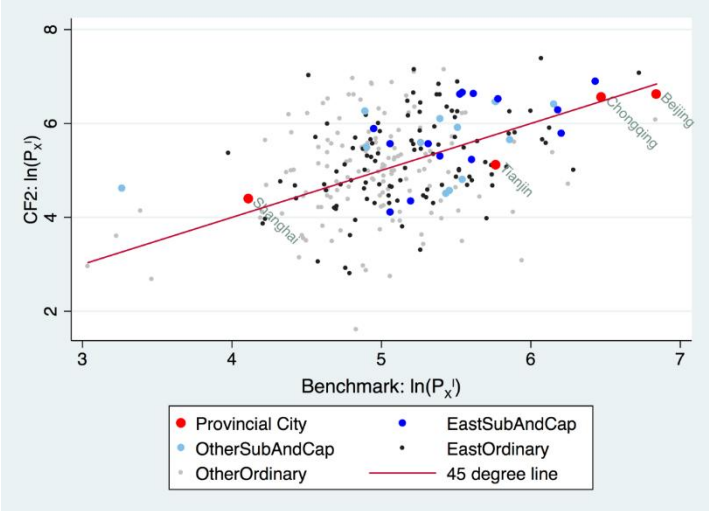
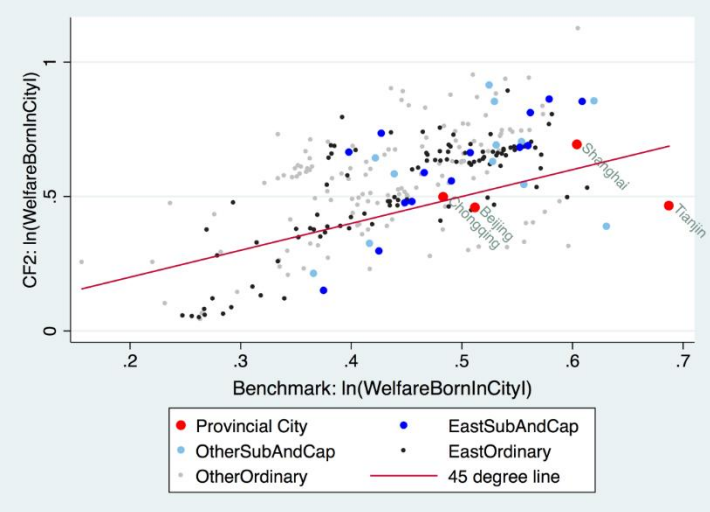


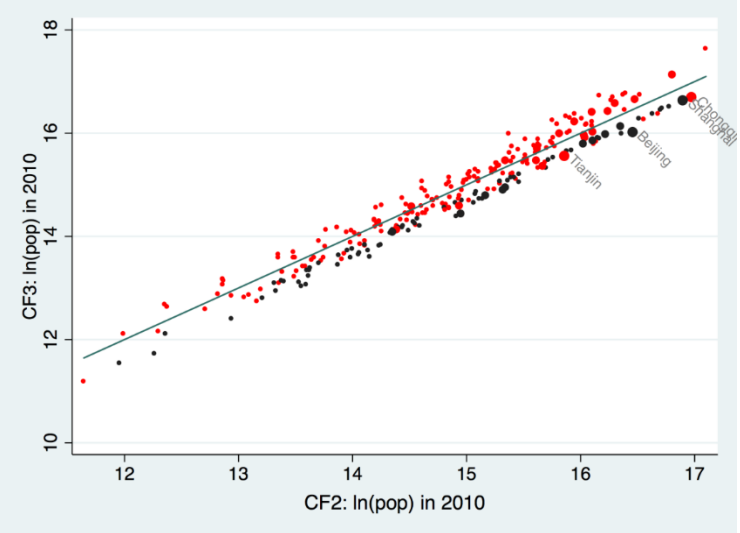

**Figure 16. Counterfactual 2: Welfare**



### 6.3 Counterfactual 3: Lowering the fixed cost of high cost destinations to that of Jiangsu

For this counterfactual, in addition to the changes in counterfactual 2, in Figure 1 we raise the ease of access across provinces to 0.34, the same as that of Jiangsu (with the corresponding adjustment to fixed costs of within province migration costs). The idea is to follow the intended national government policy of diverting migration away from favored provinces, towards hinterland ones. As a counterfactual this is strained, in the sense the government can ease hukou based restrictions for migrants to these less favored places, in terms of access to housing, education, and social services. However, it can't install strong migration networks in these locations, although it could facilitate job and house search. Nevertheless in Figure 17 we show the impact on populations. Cities in provinces with lowered fixed cost are denoted in red. Mostly they gain population while cities in black lose. In Table 6a, lowering these frictions has a significant impact on aggregate output and capital income raising those relative to counterfactual 2 by 5.4%. Worker welfare rises enormously but of course that is mostly the mechanical effect of lowered utility loss from lowering migration barriers. From Table 6b the population changes for Beijing and Shanghai are enormous. So while raising the doorsill may not do much to limit Beijing's population, removing capital market biases and making it easier to move elsewhere could have profound impacts. However if much of reducing costs of access involves having better migration networks developed through high prior migration flows, then there may be little the government can do.

**Figure 17. Counterfactual 3: Populations**



## 7. Conclusions

China has experienced enormous economic growth over the last 35 years, driven by reforms in output markets. Reforms in factor markets have been slower and the paper tries to get a handle on the gains to be made by key reforms. One is reforming capital markets so all cities and firms compete on a level playing field, eliminating favoritism of certain types of cities and firms. A second is reforming local land markets so industrial land allocations are not favored over residential ones. Such favoritism arises from local leaders giving a weight to GDP enhancement, as opposed to focusing just on maximizing welfare of residents in deciding how to allocate land and raise money from land sales to finance infrastructure benefiting firms. Leveling the playing field in capital markets and reallocating land towards residential use would increase aggregate welfare by 13%, a huge amount. It would lower the population of the biggest cities like Beijing and Shanghai and lower housing prices everywhere, in a context where rising housing prices in Chin are a critical political and social issue.

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

## Appendix

### 1. Calibration strategy

We use the following procedure to calibrate the whole economy:

**Step 1**: use data of pop $\tilde{L}_n$, $\tilde{L}'_i$, and the estimated $\mathrm{d_{ni}}$, solve for $\mathrm{Z_i}V_i$ in the migration flow equation, i.e. $\tilde{L}'_i = \sum_{\mathrm{n}\in\mathrm{N}} \frac{(Z_i V_i d_{ni})^{\theta}}{\sum_{k\in N}(Z_k V_k d_{nk})^{\theta}} \cdot \tilde{L}_n$. After that, we are able to get the migration share for each pair: $\mathrm{M_{ni}} = \frac{(Z_i V_i d_{ni})^{\theta}}{\sum_{k\in N}(Z_k V_k d_{nk})^{\theta}}$.

**Step 2**: By $L_i = \sum_{\mathrm{n}} \tilde{\mathrm{L}}_{\mathrm{n}} \cdot \mathrm{M}_{\mathrm{ni}}^{1-\frac{1}{\theta}} \cdot \Gamma\left(1-\frac{1}{\theta}\right) = \sum_{\mathrm{n}} \tilde{\mathrm{L}}_{\mathrm{n}} \cdot \mathrm{M}_{\mathrm{ni}}^{1-\frac{1}{\theta}} \cdot \Gamma\left(1-\frac{1}{\theta}\right)$, we can directly derive $\mathrm{L_i}$ for each city.

**Step 3:** Calibrate the local economy: given we've known all the parameters and $L_i$, especially $\gamma$:

- We can recover $A_n$ from the total output (Y) equation:

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

- Recover $A_n$' for each city from

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

Use the formula for V in section (7b), we are able to pin down V; recall $\mathrm{Z_i}V_i$ in step1, we then can back out $\mathrm{Z_i}$. $\mathrm{K_I}$, $\mathrm{K_R}$, $\mathrm{X_I}$ and $\mathrm{X_R}$ can be derived from equations (3), (8), (4) and (9), respectively. And w, P and G come from (2), (6) and (11b).

### 2. Solve for the optimal plan of land allocation of local government

Recall that the quantity form of output and base utility for local economy are given by

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

$$\mathrm{V} = \mathrm{Z} \cdot [\alpha_X + (1-\rho)\beta\alpha_L]^{\frac{\gamma}{\alpha_L-\gamma} - \mathrm{g}\frac{\gamma}{\alpha_L-\gamma+\alpha_X}} \rho^{\beta\rho} \beta^{-\beta(1-\rho)}$$

$$\cdot \alpha_{\mathrm{L}}^{1-\beta(1-\rho)} \cdot \alpha_{\mathrm{X}}^{\frac{\alpha_X}{\alpha_L-\gamma} - \mathrm{g} + \beta(1-\rho)} \cdot \alpha_{\mathrm{K}}^{\frac{\alpha_K}{\alpha_L-\gamma} - \mathrm{g}\frac{\alpha_K}{\alpha_L-\gamma+\alpha_X}}$$

$$\cdot \mathrm{A}'^{\frac{1}{\alpha_L-\gamma} - \mathrm{g}\frac{1}{\alpha_L-\gamma+\alpha_X}} \cdot \mathrm{L}^{\frac{\epsilon+\gamma}{\alpha_L-\gamma} - \mathrm{g}\frac{\epsilon+\alpha_L}{\alpha_L-\gamma+\alpha_X}}$$

$$\cdot \mathrm{r}^{-\left(1-\beta(1-\rho)\frac{\alpha_K}{\alpha_L-\gamma+\alpha_X}\right)-\beta\rho}$$

$$\cdot \mathrm{X}_{\mathrm{I}}^{(1-\beta(1-\rho))\frac{\alpha_X}{\alpha_L-\gamma+\alpha_X}} \cdot \mathrm{X}_{\mathrm{R}}^{\beta(1-\rho)},$$

where $\mathrm{g} = \frac{\alpha_X}{\alpha_L-\gamma} + \beta(1-\rho)$.

Substituting into the local government's objective function $\mathrm{Y}^{\mathrm{f}}V^{1-f}$, we have

$$\mathrm{Y}^{\mathrm{f}}V^{1-f} \propto X_I^{\frac{\alpha_X}{\alpha_L-\gamma+\alpha_X}(f+(1-f)[1-\beta(1-\rho)])} X_R^{\beta(1-\rho)(1-f)}.$$

Given that $\mathrm{X_I} + X_R = \bar{X}$ and taking effective labor $L$ as given, we know the optimal plan for land allocation is such that

$$\mathrm{X_I} = \frac{\frac{\alpha_X}{\alpha_L-\gamma+\alpha_X}(f+(1-f)[1-\beta(1-\rho)])}{\frac{\alpha_X}{\alpha_L-\gamma+\alpha_X}(f+(1-f)[1-\beta(1-\rho)]) + \beta(1-\rho)(1-f)} \cdot \bar{X},$$

$$\mathrm{X_R} = \frac{\beta(1-\rho)(1-f)}{\frac{\alpha_X}{\alpha_L-\gamma+\alpha_X}(f+(1-f)[1-\beta(1-\rho)]) + \beta(1-\rho)(1-f)} \cdot \bar{X}.$$

This implies the relative ratio between industrial land and residential land as

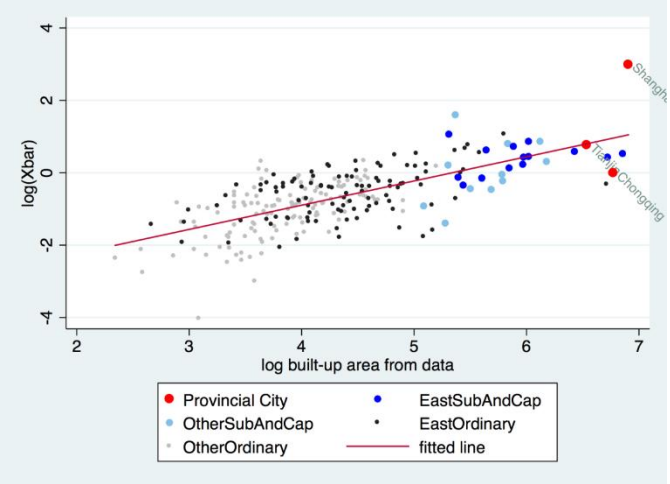
$$\frac{\mathrm{X_I}}{X_R} = \frac{\alpha_X}{\alpha_L-\gamma+\alpha_X} \cdot \frac{(f+(1-f)[1-\beta(1-\rho)])}{\beta(1-\rho)(1-f)}.$$

Dividing the F.O.C. of $\mathrm{X_R}$ over the F.O.C. of $\mathrm{X_I}$ gives us the relation between $\mathrm{P_X^R}$ and $\mathrm{P_X^I}$, where

$$\frac{\mathrm{P_X^R}}{P_X^I} = \frac{(1-\rho)\beta\alpha_L}{\alpha_X} \cdot \frac{X_I}{X_R} = \frac{\alpha_L}{\alpha_L-\gamma+\alpha_X} \cdot \left(\frac{1}{1-f} - \beta(1-\rho)\right).$$

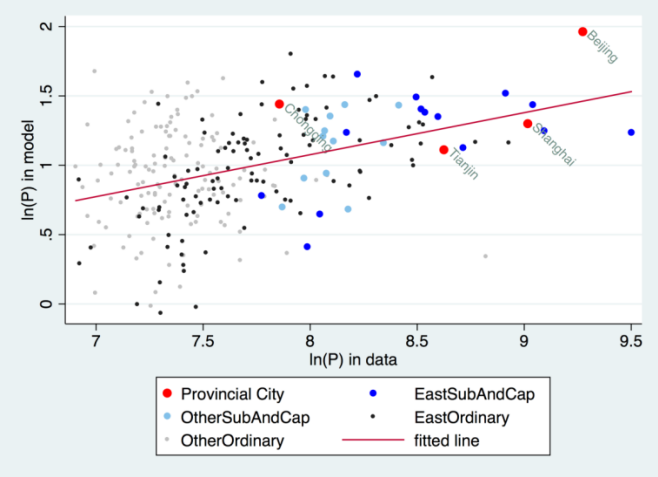
## 3. Other calibration results

## Figure A3.1 Land supply variable

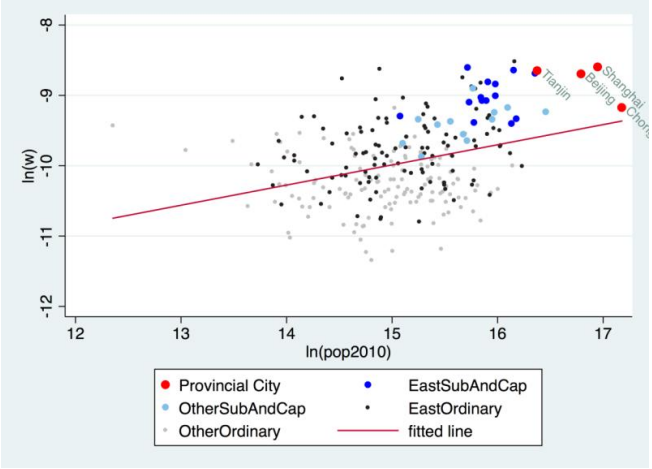



Built up area is just for urban districts

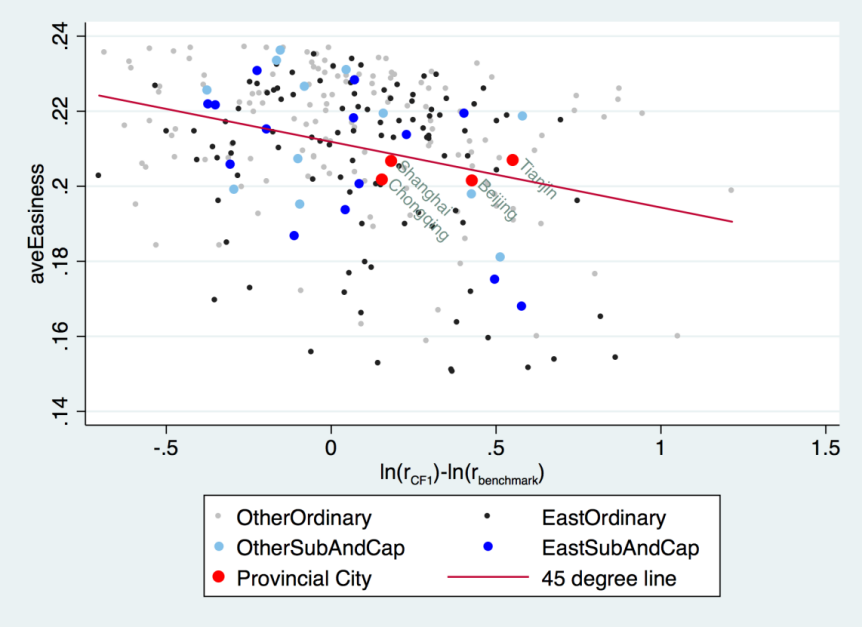
## Figure A3.2. Housing Prices




## Figure A3.3. Effective Wage



## 4. Counterfactual 1 detail




On the x-axis is the degree to which price rises. On the y-axis is the average easiness-to-access for each city, defined as $d_n = \frac{\sum_i Z_i V_i d_{ni}}{\sum_i Z_i V_i}$, which is weighted by the amenity and base utility of living at destination city i. Cities with greater rises in prices have poorer access to jobs elsewhere. They also tend to be cities that had lower welfare to begin with. This implies people born in such cities are stuck with their worsening hometowns.

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