Spatial Misallocation in Chinese Housing and Land Markets

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Abstract

Housing and land prices in China have experienced dramatic growth in the past decade. In conjunction with the rapid growth, housing and land price dispersion across Chinese cities have also become more dispersed. This paper intends to explore how market frictions affect the aggregate as well as the spatial distribution of prices. We first document the spatial variations of housing and land market frictions. Larger cities receive less housing and land subsidizes. Land frictions are improving over time. We then embed both frictions into a dynamic competitive spatial equilibrium framework featured with endogenous rural-urban migration. The calibrated model can reasonably mimic the price growth in the data. The counter-factual results suggest that the frictionless economy leads to a slower housing price growth but faster land price growth. In addition, land frictions tend to inhibit land price growth while housing price growth will slow down if only housing frictions are eliminated.

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1 Introduction

Over the past three decades, several major developed and developing economies have experienced sizable housing booms over prolonged periods. China —the world's factory— is one of the most prominent cases of rapid growth. Compared housing price growth with the speed of structural transformation, China's urbanization process has been relatively moderate, with the rural population dropping from about three-quarters to still more than half over the same period. Given this moderate urbanization pace, it is to some degree puzzling why China has experienced one of the most noticeable price hike's in urban housing markets, leading its government to implement regulatory mortgage and sales policies to cool off the housing market even shortly after the financial tsunami.[1] In addition, we have also observed a large dispersion of housing and land prices across Chinese cities. This is likely due to different local government institutions and management practices, which cause market frictions to vary across space. The primary purpose of this paper is to investigate how the housing and land market frictions affect the housing and land price growth, as well as the dispersions of the prices across cities. We propose that the large dispersion of housing and land prices are likely due to different local government institutions and management practices, which cause market frictions to vary across space.

In this paper, we develop a dynamic competitive spatial equilibrium framework to incorporate both housing market friction and land market friction, which aim to highlight land is never simply a derived demand of housing in China. The model is also featured with endogenous rural-urban migration to mimic the rapid structural transformation process undertaken in China. We highlight the existing frictions in housing and land markets may affect the population distribution. Since the housing supply is relatively inelastic due to heavy regulations on land supply and the market entrance of real estate developers, as a result housing and land price may vary significantly across cities. The growth pattern of prices are mainly driven by the improvement of manufacturing productivity over time, which generates high

[1]Based on the 2000 census, about 87 percent of Chinese households owned houses. According to the National Bureau of Statistics of China, the total residential investment in urban areas reached nearly 57.8 trillion RMB in 2012, which is 100 times more than it was in 1998. The rising demands have led to a surge in housing prices (as documented below). The processes of China's structural transformation and urbanization and its migration policies and the deregulation of housing markets are summarized in Appendix A.

incomes in urban areas and greater ability to pay for housing.

To motivate the main mechanism in our paper, we further report cross-city data of structural transformation, migration flows, and housing prices in Figure C.1. The top panel plots the average annual growth rate of housing prices against the average annual growth rate of net migration from rural areas to China's 29 major cities from 1998-2007.[2] The positive relationship suggests that housing prices grow faster in cities with larger net inflows of migrants from rural areas. The bottom panel plots the average annual growth rate of the employment share in the non-agricultural sector against the average annual growth rate of migration from rural areas to the 29 cities. The positive relationship implies most migrants from rural areas work in the non-agricultural sector in the cities. These two observations together are consistent with the idea that workers migrating from rural areas to cities most likely have switched from agricultural to non-agricultural jobs. As such, cities offering more non-agricultural jobs can potentially attract more migrants, which in turn can lead to faster housing price growth.

In our theoretical framework, we consider an economy that is geographically divided into two regions: a rural area that produces agricultural goods and an urban area (city) that produces manufactured goods (inclusive of urban services in the remainder of the paper). Ongoing technological progress drives workers away from the rural agricultural sector to the urban manufacturing sector. In the baseline model, we assume that workers arriving in a city must purchase a house with a down payment and a long-term mortgage and that, while a house is required for urban living, it has no resale value. New homes are built by real estate developers who purchase land and construction permits from the government. Our basic framework considers only a single urban area and then it is generalized to multiple cities. This extension allows us to assess the contribution of the spatial differences of frictions to changes in housing price growth rates across cities. More importantly, the multi-city framework provides theoretical guidance to our procedure in estimating city-level housing and land frictions.

We show that housing and land frictions vary substantially across cities. The average friction in housing market is about -0.97 with a standard deviation of 0.96 percent, and the

[2]This list includes all the first-tier and major second-tier cities in China.

average friction in land market is about 0.05 with a standard deviation of 3.37 percent. This implies housing developers need to pay an extra amount equivalent to 5 percent of the land sales revenue in order to input land into housing production. As a compensation, housing developers also obtain additional revenue equivalent to 97 percent of housing sales revenue. Note that land frictions appear to be negative in most cities except among largest cities. This suggests land cost are essentially subsidized in most cities. Throughout the years, the national median of each friction is always smaller than the mean, suggesting that the distributions across the cities are skewed to the right and some cities experience particularly high frictions. The frictions exhibit large variations across the cities. The 75 percentile of the housing frictions across cities are subsidized at about 37 percent of housing sales revenue, while the 25 percentile are subsidized roughly equivalent to the housing sales revenue, 93 percentage points higher than those at the 75 percentile. Land frictions exhibit similar spread: cities at the 75 percentile are subsidized at a level equivalent to 6 percent of the land sales revenue while cities at the 25 percentile enjoy a 68 percent subsidy, 62 percentage points higher than those at the 75th percentile. The spatial spread of both frictions also appear to be persistent across the years.

To disentangle the contributions of both housing and land frictions in driving both the price growth and spatial dispersion of prices, we have performed various counter-factual exercises in which we either eliminate all the frictions, or only eliminate housing or land frictions. we calibrate the model to mimic the early stages of development in China from 1980 to 2012. The future projected path for China's structural transformation through 2063 is based on the U.S. experience from 1950 to 1990. We restrict our attention to the period from 2007 to 2013. This is because China's pre-2007 land market was not fully marketized and land prices were heavily regulated.

The main findings can be summarized as follows. At the national level, the process of structural change can account for 95.5 (87.3) percent of housing (land) price ratio in 2013 to 2007. In terms of the annual growth rate, the model can account for 87.3 and 128.2 percent of the changes in the data counterpart. When all the frictions are eliminated, housing and land prices are about 68.7 and 61.6 percent of their benchmark counterparts. Land friction exerts no role in housing prices and thus housing friction is important in driving housing price growth. However, the contribution of each friction to land price growth varies by year.

In the multiple-city case, the coefficient of variation for housing and land prices have decreased by 20 and 45 percent, respectively, if we eliminate all the frictions. If we eliminate the spatial differences of housing frictions among cities, the dispersion of housing price is the same as the frictionless case. This suggests that it is not the level of housing frictions at each city but the spatial difference of the housing frictions that drive up the housing price disparity. As for land prices, our results suggest that land friction contributes to the land price dispersion. Overall, the model underpredicts housing price ratio in 60 cities, and overpredicts land price ratio in 40 cities. On average housing and land price ratio is about 0.95 and 1.92 times of their data counterparts.

Literature Review

The Chinese economy has undergone many political and economic reforms since 1978. Its rapid growth has made it the second-largest economy in the world, with especially significant growth since 1992. There is a large literature studying the development of China. For brevity, the reader is referred to Zhu (2012) for an extensive summary of the various stages of economic development. There is a small but growing literature investigating China's housing boom, including research by Chen and Wen (2014), Fang, Gu and Zhou (2014), and Deng, Gyourko, and Wu (2015). In contrast to this literature, we highlight the structural transformation of the manufacturing sector as a key driver of rural migrants to the cities. There have been numerous studies on structural transformation using dynamic general equilibrium models without spatial considerations. For a comprehensive survey, the reader is referred to Herrendorf, Rogerson, and Valentinyi (2014). Of particular relevance, Hansen and Prescott (2002) and Ngai and Pissaridis (2007) emphasize the role of different total factor productivity (TFP) growth rates played in the process of structural change. In our paper, the productivity gap between urban and rural areas is a main driver of ongoing rural-urban migration.

The literature of dynamic rural-urban migration is much smaller. While Glomm (1992) studies rural-urban migration as a result of higher urban productivity due to agglomerative economies, Lucas (2004) highlights a dynamic driver of such migration, the accumulation of human capital and hence the ongoing rise in city wages. More recently, Bond, Riezman, and

Wang (2014) show that trade liberalization in capital-intensive import-competing sectors prior to China's accession to the WTO has accelerated the migration process and capital accumulation, leading to faster urbanization and economic growth. Tombe and Zhu (2015) find that reduction in internal trade and migration costs accounted for almost two-fifth of aggregate labor productivity growth in China over 2000-2005, even more important than international trade liberalization. Also focusing on China, Liao et al. (2014) find that education-based migration plays an equally important role with work-based migration in the process of urbanization. None of these papers study housing markets.

In our paper, migration increases the demand for residential housing and thus affects prices. To isolate the contribution of migration flows to housing prices, in the model, housing demand is determined only by migrants moving from rural areas to cities (the extensive margin). This formalization contrasts with a large literature using general equilibrium asset pricing frameworks (e.g., Davis and Heathcote, 2004), where prices are determined by a representative individual who adjusts the quantity of housing consumed. From the housing supply perspective, our model emphasizes the role of government restrictions on the production of housing units. By further incorporating limited access to the financial market for housing purchases, the analysis in our paper is connected to a large literature that explores financial frictions as drivers of housing boom-bust episodes (e.g., see papers cited by Garriga, Manuelli, and Peralta-Alva, 2012). In contrast to these housing papers, our paper focuses on the economic development angle with the migration decision endogenously determined in the model.

2 Theoretical Framework

The economy is divided into two regions, namely, urban and rural area. A unique type of consumption goods is produced in the urban area. Time is discrete and infinite indexed by $t = 0, 1, 2....$ There is a mass one of continuum and infinitely-lived workers who initially lived in the rural area in $t = 0$. Workers are all identical except for the costs of migration from rural to the urban area measured in term of utilities.

The payoff from staying in the rural is exogenous and normalized to be $\underline{U}$. City workers obtain utilities from consumption good and housing. Housing is assumed to be a necessity and satiated good for city workers. Specifically, utility function for city workers takes the following form:

$$U(c_t^m, h_t) = \begin{cases} u(c_t^m) & \text{if} \quad h_t \geq 1 \\ -\infty & \text{otherwise,} \end{cases}$$

where we assume $u'(\cdot) > 0$ and $u''(\cdot) < 0$, and city workers need to live in 1 unit of house in order to survive in the city. Moreover, since workers do not gain additional utilities from possessing more than 1 unit of house, and thus in the equilibrium each city worker demands 1 unit of house.

Workers who have been in the city for more than one period have two state variables: their utility cost from migration, ϵ, and mortgage debt from purchasing a house at time τ, b_τ. Let $V_t^C(\epsilon, b_\tau)$ represent the lifetime payoff for a worker with disutility level ϵ and mortgage debt b_τ. The worker derives current utility $U(c_t^m, h_t)$ and discounts future payoffs at rate β by choosing between staying in the city, $V_{t+1}^C(\epsilon, b_\tau)$, and returning to the rural area, $V_{t+1}^R(\epsilon)$. The worker spends his wage income, w_t, on consumption goods and mortgage debt repayment, $b_\tau r^*$. The optimization problem for a worker that moved in $\tau < t$ can be specifically summarized as:

$$\begin{aligned} V_t^C(\epsilon, b_\tau) = \max U(c_t^m, h_t) \quad &+ \quad \beta \max\{V_{t+1}^C(\epsilon, b_\tau), V_{t+1}^R(\epsilon)\} \\ s.t. \qquad c_t^m + b_\tau r^* \quad &= \quad w_t \end{aligned}$$

2.1 Migration Decisions

During the initial period τ when a rural worker moves to the city, he must purchase a house at price q_τ. A house purchase is financed with an infinite consol fixed-rate mortgage and requires a down payment, which is an exogenous fraction ϕ of the housing price in the moving period τ . In the following periods, the specified repayment is a constant d_τ. d_τ can be derived by equating the size of the loan to the present discounted value of all mortgage payments:

$$(1-\phi) q_\tau h_\tau = \sum_{t=\tau+1}^{\infty} \frac{d_\tau}{(1+r^*)^{t-\tau}}.$$

Given the constant interest rate, r^*, the constant payment is simply

$$d_\tau = (1-\phi) r^* q_\tau h_\tau. \tag{1}$$

We assume the mortgage contract satisfies $\phi > \frac{r^*}{1+r^*}$ to ensure that the down payment exceeds the mortgage payment each period. Notably, one may consider a city economy with all workers renting houses from absentee landlords who purchase them in advance to fill the demand. Maintaining the same housing demand structure, one may then capture this pure rental case by setting $\phi = r^*/(1+r^*)$, under which an agent migrating in period τ signs a long-term rental agreement paying a rent d_τ every period based on the housing price.[3] Thus, the pure rental market can be viewed as a special case of our model.

The optimization problem of rural workers who move to the city in period τ is represented by:

$$\begin{aligned} V_\tau^M(\epsilon) = \max U(c_\tau^m, h_\tau) &+ \beta \max\{V_{t+1}^C(\epsilon, b_\tau), V_{t+1}^R(\epsilon)\} \\ s.t. \qquad c_\tau^m + p_\tau h_\tau &= w_\tau + b_\tau \\ b_\tau &\leq (1-\phi) p_\tau h_\tau. \end{aligned}$$

The problem above is subject to a traditional budget constraint at the migration stage including a down payment, the purchase of goods, and a borrowing constraint associated with mortgage financing.

Given the expressions for $V_\tau^M(\epsilon)$, and $V_\tau^R(\epsilon)$, we can determine the conditions under which workers with migration cost ϵ move into the city at time τ as follows:

$$V_\tau^c(\epsilon) - \epsilon \geq \underline{U}. \tag{2}$$

Workers will migrate to the city if and only if the payoff from migration is greater than from staying in the rural area. There exists an ϵ_τ^* that solves $V_\tau^M(\epsilon_\tau^*) - \underline{U} = \epsilon_\tau^*$ and determines the cutoff level of rural workers who migrate to the city in any given period.

[3] Similar to the case of resales, allowing for a one-period rental agreement would make the model intractable because a migrant's decision would then depend on the entire path of current and future housing prices (and hence migration flows).

2.2 Production

The manufacturing goods market is assumed to be perfectly competitive. There is a mass one of continuum of manufacturing producers who are endowed with K_0 capital in $t = 0$. Production of manufacturing goods require capital and labor as input:

$$Y_t = A_t^m N_t^{1-\sigma} K_t^{\sigma},$$

where $\sigma \in (0, 1)$ captures capital share and A_t^m is the exogenous total factor productivity in manufacturing sector at t. Capital in the manufacturing sector accumulate over time according to:

$$K_{t+1} = K_t^{1-\delta} I_t^{\delta},$$

where $\delta \in (0, 1)$ denotes the capital depreciation rate.

Manufacturing firm in each period makes the investment and employment decision to maximize the present value of future profits. Specifically, we can formulate its optimization problem recursively as follows:

$$\begin{aligned} V_t(K_t) = \max_{K_{t+1}, N_t} A_t^m K_t^{\sigma} N_t^{1-\sigma} - w_t N_t \quad &- \quad I_t + \beta V_{t+1}(K_{t+1}) \\ \text{s.t.} \quad K_{t+1} \quad &= \quad K_t^{1-\delta} I_t^{\delta} \end{aligned}$$

2.3 Government

In the model economy land is owned and supplied by the government. Each period, the government determines the amount of land available for housing developers. The total land area in the city is normalized to 1. The government decides to add $\ell_t \geq 0$ units of land for building houses at time t. The aggregate law of motion for land is represented by

$$L_t = \ell_t + L_{t-1},$$

where the aggregate land area occupied by houses in the city cannot exceed 1 (i.e., $L_t \leq 1, \forall t$). Since the average house size is fixed, the law of motion for the housing stock is entirely characterized by the fraction of movers, ΔF_t^*, and existing individuals in the city, H_{t-1} :

$$H_t = H_{t-1} + \Delta F_t^*,$$

where H_{t-1} represents the number of houses that the government has granted permission to build up to in period $t-1$

The government not only controls the supply of land but also charges a fee, Ψ_t, in units of manufactured goods, to housing developers, which determines the number of permits granted:

$$\Psi_t = \psi H_{t-1}^{\eta},$$

where the average land leasing fee, $\psi > 0$, is constant over time. A larger number of permits granted in the past, H_{t-1}, implies a higher fixed construction fee. This assumption captures public concern about congestion and overcrowding in cities.

2.4 Housing Developers

Each housing developer is endowed with the technology to convert land together with construction material into houses. The production function takes a simple form:

$$h_t = A_t^h (z_t - \underline{z}_t)^{\gamma} I_{ht}^{\alpha}, \quad 0 < \alpha + \gamma < 1, \alpha > 0, \gamma > 0.$$

$\underline{z}_t > 0$ denotes the minimum land requirement to build house. z_t and I_{ht} denote the land and construction input, respectively. The presence of decreasing returns to scale is necessary to allow for a developer to cover the fixed cost incurred from paying for a permit. Each housing developer is assumed to live for only one period and is replaced by an identical agent. This assumption, based on convenience, eliminates the complication of managing inventories of land. An incumbent developer needs to decide how much land to buy to maximize the operative profit Π_t^d. Upon receiving revenue from selling houses, the developer must pay a fixed cost to the government.

A representative incumbent housing developer's optimization problem is characterized as:

$$\Pi_t^d = \max_{z_t, I_{ht}} \quad p_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha - q_t z_t - p_{ht} I_{ht},$$

where p_t represents the selling price of a new housing unit at the end of period t, and q_t is the land price that a housing developer must pay to the government. p_{ht} is the cost per unit of construction material, and we assume it is exogenously given.

We assume there are many housing developers each period. The equilibrium entry level of housing developers, S_t, is pinned down by the following free-entry condition:

$$\Pi_t^d = \Psi_t.$$

2.5 Competitive Spatial Equilibrium

We first formalize the definition of equilibrium in our benchmark economy with a rural area and a urban area, then we proceed to characterize several equilibrium properties.

Definition: Given exogenous parameters $\{\ell_t, p_{ht}, A_t^m, A_t^h\}_{t=0}^\infty$ and initial conditions H_0 and K_0, a *competitive spatial equilibrium* consists of a list of prices $\{p_t, q_t, w_t\}_{t=0}^\infty$, individual quantities $\{h_t, c_t\}_{t=0}^\infty$, a migration cutoff value $\{\epsilon_t^*\}_{t=0}^\infty$,capital stock path $\{K_t\}_{t=0}^\infty$ and an employment vector $\{N_t^m, S_t\}_{t=0}^\infty$ that satisfies

1. Workers and housing developers problem
2. There is a cutoff of mobility cost ϵ_t^*
3. The number of housing developers is determined by the free entry condition
4. Markets clear
   (a) land: $S_t z_t = \ell_t$
   (b) housing: $S_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha = F(\epsilon_t^*) - F(\epsilon_{t-1}^*)$
   (c) manufactured goods (redundant by Walras' law)

Given wage rate w_t and capital stock K_t, manufacturing firm's labor demand in t satisfies:

$$N_t = (1-\sigma) A_t^m (\frac{K_t}{N_t})^\sigma$$

The value function can thus be rewritten as:

$$\begin{aligned} V_t(K_t) = \max_{K_{t+1}} \sigma A_t^m K_t^\sigma N_s^{1-\sigma} \quad &- \quad I_t + \beta V_{t+1}(K_{t+1}) \\ \text{s.t.} \quad K_{t+1} \quad &= \quad K_t^{1-\delta} I_t^\delta \end{aligned}$$

Steady-state capital stock,K_s, thus satisfies:

$$\beta\delta\sigma^2 A^m K_s^{\sigma-1} N_s^{1-\sigma} = 1 - \beta(1-\delta)$$

In the following, we turn to solve for housing developer's optimization problem.[4] The results suggest:

$$\frac{\gamma I_{ht} p_{It}}{\alpha q_t (z_t - \underline{z}_t)} = 1 + \tau_{zt} \tag{3}$$

$$1 - \tau_{ht} = \frac{q_t (z_t - \underline{z}_t)(1 + \tau_{zt})}{\gamma p_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha} \tag{4}$$

If we assume $\underline{z}_t = \varsigma_t z_t$, free entry condition then gives:

$$\begin{aligned} z_t &= \left[\frac{\ell_t A_t^h (1-\varsigma_t)^\gamma I_{ht}^\alpha}{N_t^d}\right]^{\frac{1}{1-\gamma}} \\ S_t &= \ell_t \left[\frac{\ell_t A_t^h (1-\varsigma_t)^\gamma I_{ht}^\alpha}{N_t^d}\right]^{\frac{-1}{1-\gamma}} \end{aligned}$$

Finally, housing market clearing condition can pin down housing price as follows:

$$p_t^{\frac{1-\gamma}{1-\gamma-\alpha}} = \frac{f_t(A_t^h)^{\frac{-1}{1-\gamma-\alpha}}}{(1-\alpha-\gamma)(1-\tau_{ht})} \left[\frac{N_t^d}{\ell_t(1-\varsigma_t)}\right]^{\frac{\gamma}{1-\gamma-\alpha}} \left(\frac{\alpha(1-\tau_{ht})}{p_{It}}\right)^{\frac{-\alpha}{1-\gamma-\alpha}} \tag{5}$$

The expression above suggest that housing price depends on the migration flow, entry cost, incremental land and friction. Land to housing price ratio is thus:

$$\frac{q_t}{p_t} = \frac{1-\tau_{ht}}{1+\tau_{zt}} \frac{\gamma N_t^d}{(1-\varsigma_t)\ell_t} \tag{6}$$

The ratio above negatively depends on both types of frictions.

[4] Appendix A offers the solution in details.

2.6 The Case of Multiple Cities

The model in the previous section restricts the analysis to a single city. We now extend the model to the case of multiple cities. Suppose there are cities $I > 1$. All of the cities are identical and have access to the same technology to produce manufactured goods that can be costlessly traded across cities. The cities differ in two aspects: (i) the availability of land (exogenously) supplied by the government, $\{\ell_i\}_{i=1}^{I}$; (ii) the city specific housing and land frictions, $\{\tau_i^h, \tau_i^z\}_{i=1}^{I}$. As a result, equilibrium wages and housing supply and demand are city specific.

In the interest of tractability, city selection is determined by lottery. The probability that a rural worker will be assigned to city i is denoted by π_i, where $\sum_{i=1}^{I} \pi_i = 1$. The city labor markets are segmented because labor mobility across cities is not permitted.[5] As a result, in equilibrium, wages across cities do not equalize. As such, once a rural worker is assigned to city i, his location choice afterward is to either continue to stay in city i or move back to the rural area.

For a worker of type ϵ, the utility cost of migrating from the rural area to any of the I cities is represented by ϵ. Let $V_{i,t}^{M}(\epsilon)$ denote the value function for a worker of type ϵ who migrates to city i in period t and solves this optimization problem:

$$V_{i,t}^{M}(\epsilon) = \max U(c_{i,t}, h_{i,t}) + \beta \max\{V_{i,t+1}^{C}(\epsilon, b_{i,t}), V_{t+1}^{R}(\epsilon)\},$$

$$s.t. \qquad c_{i,t}^{m} + p_{i,t}h_{i,t} = w_{i,t} + b_{i,t},$$

$$b_{i,t} \leq (1-\phi)p_{i,t}h_{i,t}.$$

This problem is similar to the one for the single-city model, but in this case wages and housing prices are determined at the city level. The ex-ante value associated with migration is represented by $V_t^M(\epsilon)$, which equals the expected payoff from living in any one of the I cities, $V_t^M(\epsilon) = \sum_i \pi_i V_{i,t}^{M}(\epsilon)$. Therefore, a worker of type ϵ will migrate to an urban area in period t when following condition is satisfied, $V_t^M(\epsilon) - \epsilon \geq \underline{U}$. In each period $t > 0$, there exists a cutoff ϵ_t^*, below which workers move to an urban area. The threshold ϵ_t^* can be

[5] Based on population census in 2005 and 2010, we calculated net migration flows from Beijing to other cities (including Shanghai) and from Shanghai to other cities (including Beijing) and found them within ± 4 percent. Thus, ignoring the city-to-city migration does not seem to be at odds with the evidence.

pinned down from the following indifference condition:

$$V_t^M(\epsilon_t^*) - \epsilon_t^* = \underline{U}$$

Housing developers in each city are endowed with the same technology to convert land into houses. The entry fee collected by the government in each city will obey these rules, so the entry fee collected by city i in period t positively depends on the existing housing stock in city i: $\Psi_{i,t} = \psi H_{i,t-1}^{\eta}$, where $\psi > 0$. Therefore, the number of housing developers in each city, $M_{i,t}$, will be determined by the following free-entry condition, $\Pi_{i,t}^d = \Psi_{i,t}$.

The housing and land markets will clear in each city subject to the exogenous land supply controlled by the government in each city. The market-clearing conditions in city i can be derived as follows:

$$S_{i,t} z_{i,t} = \ell_{i,t},$$
$$S_{i,t} A_{i,t}^h z_{i,t}^{\gamma} I_{i,ht}^{\alpha} = \Delta F_{i,t}^*.$$

3 Calibration and Estimation

3.1 Data

In order to estimate city-specific housing and land frictions[6], we need the following data information at city-level: (1) Real average price of newly-built housing units; (2) Real average price of residential land parcels; (3) Floor area of newly-built housing units sold; (4) Investment on housing development (exclude land purchase); (5) Residential land sales; (6) Real unit construction cost. Due to the data availability, we have finally selected a balanced panel of 93 major Chinese cities. The total population and GDP among the 93 cities take up roughly a fraction of 60 and 70 of the entire country. In Figure C.2 we map the selected cities in our sample.

During 2007-2013, the average annual growth rate of housing and land prices among our selected cities is 8.92 and 19.92 percent, respectively. The top 3 cities with the highest

[6] We will describe the estimation procedure in details in Section 3.2.

housing price growth rate are Ganzhou, Jiujiang and Luzhou, and the bottom 3 cities with the lowest housing price growth rate are Tongling, Dalian, and Daqing. Similarly, the top 3 cities with the highest land price growth rate are Wuxi, Zhanjiang and Xining, while the bottom 3 cities are Baoji, Panzhihua and Tongling. We map the distribution of housing and land price growth rate in Figure C.3. An alternative measure of price growth is the ratio of housing and land price in 2013 to that of 2007, which is also summarized in C.3. The top 3 cities with the highest housing price ratio of 2013 to 2007 are Ganzhou, Luzhou and Zunyi, and the bottom 3 cities are Xiangfan, Dalian and Tianjin. Similarly, the top 3 cities with the highest land price ratio of 2013 to 2007 are Shaoguan, Guilin and Dandong, and the bottom 3 cities are Lanzhou, Qinghuangdao and Wenzhou. In Table C.4 we also mapped both housing and land price levels in year 2013. The unit is RMB per square meters in 2010 RMB. The top 3 cities with the highest housing price level are Shenzhen, Beijing and Shanghai, respectively. They all belong to the tier-1 cities in China. There are in total 10 cities in our sample with housing price exceeding ten thousand RMB per square meter in 2013. The top 3 cities with the most expensive land are in turn: Shenzhen, Sanya and Xiamen, respectively.

3.2 Estimation of Frictions

According to the previous theoretical results, we can estimate the city-level housing and land market frictions as:

$$\begin{aligned} 1+\tau_{zt} &= \frac{\gamma I_{ht} p_{It}}{\alpha q_t (z_t - \underline{z}_t)} \\ 1-\tau_{ht} &= \frac{q_t (z_t - \underline{z}_t)(1+\tau_{zt})}{\gamma p_t A_t^h (z_t - \underline{z}_t)^{\gamma} I_{ht}^{\alpha}} \end{aligned}$$

$I_{ht} p_{It}$ refers to the investment on housing development excluding land purchase expenses in the data. $q_t(z_t - \underline{z}_t)$ is land sales revenue and $p_t A_t^h (z_t - \underline{z}_t)^{\gamma} I_{ht}^{\alpha}$ is housing sales revenue, which is computed using data on floor area of newly-built housing units sold combined with the relevant price information. In addition, we also need to back out the parameter value for α and γ, which is the construction material share and land share in the housing production.

To achieve this end, we run the following panel regression:

$$\log(q_{it}) = c + \beta_1 \log(\ell_{it}) + \beta_2 \log(I_{it}) + \beta_3 t + \delta_i + \epsilon_{it} \tag{7}$$

where q_{it} is floor area of newly-built housing units sold measured in 10,000 sq.m. ℓ_{it} is residential land sales measured in 10,000 sq.m. I_{it} is construction material and we compute it by dividing the residential investment excluding land purchase by the real unit construction cost. We have included a time trend and controlled all the city fixed effects. The estimated coefficient then β_1 and β_2 corresponds to α and γ, respectively.

The summary statistics for our estimated city-level housing and land market frictions are presented in Table C.1. Our results suggest the average friction in housing market is about -0.97 with a standard deviation of 0.94 percent, and the average friction in land market is about -0.26 with a standard deviation of 0.69 percent. This implies housing developers are subsidized at an amount equivalent to 26 percent of the land sales revenue in order to input land into housing production. Similarly, housing developers also obtain additional revenue equivalent to 97 percent of housing sales revenue. Note that land frictions appear to be negative in most cities. Throughout the years, the national median of each friction is always smaller than the mean, suggesting that the distributions across the cities are skewed to the right and some cities experience particularly high frictions. The frictions exhibit large variations across the cities. The 75 percentile of the housing frictions across cities are subsidized at about 37 percent of housing sales revenue, while the 25 percentile are subsidized roughly equivalent to 1.35 times of the housing sales revenue, 98 percentage points higher than those at the 75 percentile. Land frictions exhibit similar spread: cities at the 75 percentile are subsidized at a level equivalent to 8 percent of the land sales revenue while cities at the 25 percentile enjoy a 69 percent subsidy, 61 percentage points higher than those at the 75th percentile. The spatial spread of both frictions is also persistent across the years. The 75-25 spread of housing frictions is -0.19 (1.07) = 88 percent in 2007, and 91 percent in 2013.

Frictions by city-tier In Table C.2, Table C.3 and Table C.4, we have presented the summary statistics within the group of tier-1, tier-2 and tier-3 cities, respectively. The following features stand out: 1) housing frictions among tier-1 cities are close to zero, and negative among tier-2 cities. Tier-3 cities receive the highest housing subsidies. This is likely due to the fact that smaller cities are less affected by the strict housing market intervention policies, which will be discussed in details later. 2) Land frictions are worsen in cities with lower tiers. This is probably because land aution are not very transparent in smaller cities. We will also dicuss more institutional backgrounds later.

In the following we explore how frictions change with respect to city size, and the results are reported in Table C.5. The first column only includes the city size measured by GDP on the right-hand-side, and it shows that larger cities are taxed more in the housing sales revenue and also subsidized more in the costs of land inputs. Doubling the GDP increases the housing frictions by 22.4 percentage points. In contrast, doubling GDP decreases the land frictions by 20 percentage points. If we include both the linear time trend and the interaction between city size and the time trend to the RHS, for housing frictions the coefficient on the interaction term is not significantly from zero. This suggests that the gaps in housing frictions between large and small cities stayed roughly the same over the years. On the other hand, for land frictions the coefficient on the interaction term is significantly positive, which implies the city size elasticity of land frictions gets closer to zero over time. Column 3 includes both year and city fixed effects to the RHS of the estimation. The coefficients on city size are no longer significantly different from zero. This suggests that those frictions are probably rooted in the time-insensitive city characteristics such as institution quality or the geographic locations that correlate with city size, and the frictions in both housing and land markets are not alleviated by economic growth over time.

The positive relation between city size and housing frictions suggest that housing is still heavily subsidized in small cities. Since 2005, the Chinese governments have implemented several rounds of strict housing market intervention policies in major cities (especially the first tier cities and a few second tier cities), with the purpose of curbing housing price surge. The major policies include restrictions on loan-to-value ratio and interest rate for housing mortgages, higher transaction taxes for housing resales, and, perhaps most importantly, restrictions on multiple home purchase for local households or any home purchase for non-resident households since 2010. However, during most periods these policies did not apply to the smaller third or fourth tier cities. By contrast, explicit or implicit housing subsidies are still prevalent in these smaller cities, especially during the stimulus period (late-2008 to mid-2010) and the destocking campaign (2015-2016). The types of subsidies vary with city, mainly including transaction tax rebating, local registered permanent residence (hukou) awarding, lower mortgage interest rates, or even monetary subsidies for home purchase.

Table C.6 reports the evolution of the frictions over time. The first column reports the regression against a linear time trend, and the results confirm an overall reduction of the land frictions over time, which suggests the land inputs become more expensive over time. The second column replaces the linear time trend with year dummies. Land frictions have been decreasing over the years steadily. Most of the reduction in housing frictions occurred in year 2008, 2012 and 2013. The last column introduces city fixed effects in addition to the year dummies. The point estimates on year dummies are mostly unaffected, suggesting again that cities experienced similar trends of frictions over the years.

The fact that land frictions decrease over time is likely due to the following policy changes. In May 2002, the Ministry of Land and Resources (MLR) required all residential and commercial land parcel leasehold purchases to be sold via some type of public auction process. This can be considered as the starting point for the development of a competitive and transparent urban residential land market. However, for most cities, especially the smaller cities, the subsequent land market development took a relatively long period of almost one decade. MLR also issued or revised several techniques codes or documents in 2004, 2006, 2007, 2009 and 2011, respectively, to further improve the competitiveness and transparency of urban land market. Generally, the urban residential land market is more competitive in larger cities, compared with the smaller cities, for at least two reasons. First, the rules associated with urban land market are typically better established in the leading cities. Second, typically there are much more developers in larger cities, and thus more potential competing buyers in the residential land market.

3.3 Estimation of Migration Probability

The multiple-city framework maintains most assumptions made in the benchmark model with the following exceptions: the exogenous probability of migrating to city i from the rural area, π_i; the relative manufacturing productivity in city i, $\{A_{i,t}\}$; and the total residential land area in city i, $\{L_{i,t}\}$. When there are $I > 1$ cities in the urban area, the share of the population in city i, $n_{i,t}$, is denoted as follows, where $N_{i,t}$ denotes the total population in city i and N_t^R denotes the total population in the rural area:

The growth rate of population in city i can be shown to be equivalent to:

$$\begin{aligned}
\frac{N_{i,t}}{N_{i,t-1}} &= \frac{N_{i,t-1} + \triangle N_{i,t}}{N_{i,t-1}}, \\
&= 1 + \frac{\triangle N_{R,t}\pi_i}{N_{i,t-1}} = 1 + \frac{(N_{R,t} - N_{R,t-1})\pi_i}{N_{R,t-1}}\frac{N_{R,t-1}}{N_{i,t-1}}, \\
&= 1 + (\frac{N_{R,t}}{N_{R,t-1}} - 1)\pi_i\frac{N_{R,t-1}}{N_{i,t-1}}.
\end{aligned}$$

From the first to the second equation above, it essentially implies the population growth rate in city i is

$$\frac{N_{i,t}}{N_{i,t-1}} = \frac{n_{i,t}}{n_{i,t-1}}, \frac{N_{R,t-1}}{N_{i,t-1}} = \frac{n_{R,t-1}}{n_{i,t-1}}, \frac{N_{R,t}}{N_{R,t-1}} = \frac{n_{R,t}}{n_{R,t-1}}.$$

Finally, we can obtain the migration probability from rural to city i in t satisfies the following:

$$\frac{n_{i,t}}{n_{i,t-1}} - 1 = (\frac{n_{R,t}}{n_{R,t-1}} - 1)\pi_{i,t}\frac{n_{R,t-1}}{n_{i,t-1}}$$

Our city-specific migration probability is a simple average of $\pi_{i,t}$ over our sample period. We also renormalize the size so that they sum up to be 1. We present the top and bottom 5 cities with the highest and lowest migration probability in Table C.7. The estimation results seem to be in line with the data. Beijing, Shanghai and Shenzhen, which usually are believed to be the main receiptant city of migrants, are all on the list of top 5 cities. Note that since the estimated migration probabilities captures the direction and magnitudes of rural population inflow into urban cities, and thus it also reflects the differences in productivities and amenities across urban cities.

The expression above also suggests in order to keep track the entire population distribution over time, we need information on initial city size distribution as well as the evolution of urban(rural) population over time. In the following, we perform urban population projection.

Projection of urban population In 1840 almost 90 percent of the total U.S. population lived in rural areas. This percentage steadily declined to about 3 percent in 1990 and has remained at about 3 percent ever since. Because the fraction of the population living in rural areas is a main indicator of the progress of structural transformation, the United States is viewed as having completed its structural transformation by 1990. In 2012, the agricultural share of employment in China is still over 30 percent and the fraction of urban employment is around 50 percent.[7]

Calculating the path of future prices requires making different assumptions about the length of the structural transformation process. In the baseline case, we assume that the path of China's structural transformation will take another 50 years since 2013. Under this assumption, in the year 2063 urban employment in China will become steady thereafter. Our algorithm is simply as follows: We assume net migration flow into urban area will continue to grow until the year 2020, and afterwards, it will steadily decline as shown in the right panel of Figure C.5. The definition of net migration flows from rural to urban areas include permanent and temporary permits where many of the latter, mostly renting, but are later granted permanent permits. Overall, the time path for the fraction of urban employment is plotted in the left panel of Figure C.5. By 2063, the fraction of urban employment will reach 95 percent.[8]

[7]While there is discrepancy in the definition of urban areas between these two large economies, the contrast is sharp regardless.

[8]Note that there may be more optimistic projections on the progress of structural transformation in China, with a much faster transition for China than the United States. The conjecture above is provided as a starting point. As a robustness check, we performed various exercises with more optimistic and pessimistic projected paths. While the results have some effects in the very long-run, but they have only a minor impact on the simulated dynamics of housing prices between 2007 and 2013.

3.4 Calibration

We parameterize the model in this section. We let the utility function take the log form $u(c_t) = log(c_t)$. A worker's disutility level from migration is assumed to follow a Pareto distribution defined over interval interval $[\underline{\epsilon}, \infty)$:

$$F(\epsilon) = 1 - \left(\frac{\underline{\epsilon}}{\epsilon}\right)^{\lambda}.$$

Each period in the model corresponds to one year; the subjective discount rate, β, is set at 0.95; and the annual interest rate, r^*, is set at 5 percent. The down payment ratio ϕ, the fraction of the house value that the worker must pay in advance is set at 0.3, which is consistent with the data. α and γ in the housing production function have been estimated in Section XX. $1 - \sigma$ and δ denote capital share and depreciation rate in the production sector, and we let it be 0.4 and 0.05, respectively, which are commonly used in the literature. λ captures the tail index of the migration cost distritution, and is calibrated to match the initial population size in 2007. ψ is the entry fee coefficient, and is calibrated to match a 3-percent entry cost to land sales ratio. η measures city size elasticity of entry fee, and we set it to be 0.5, which will be subjected to sensitivity analysis. $\underline{z}_t$ is the minimum land requirement, and we set it to be 10 percent of land purchased by each housing developer. We summarize the benchmark parameterization in Table C.8.

From the panel regression in Equation 7, we can obtain the residual term ϵ_{it}. The productivity in the housing sector, A_{ht}, is then assumed to be a geometry average of the ϵ_{it} across all the cities. We also examine whether there is a time trend in the estimated series within the sample period. If there is one, we extrapolate for those that are out of our sample periods. We also perform a similar projection algorithm for the residential land supply at city-level. We approximate city-level land sales by fitting the available land sales data with the following regression equation:

$$log(\ell_{it}) = b_{0i} + b_{1i}t + \varepsilon_{it}, \quad i = 1, 2...J$$

Note that our data suggests the declining trend of residential land supply—$\hat{b_{1i}} < 0$—can only be perceived in 13 cities.[9] We again extrapolate the land data for 20 periods, and let the land supply in the remaining periods maintain at its mean level over the first 20 periods. We perform similar exercises for τ_{ht} and τ_{zt}. We follow same prediction as when we project urban population by letting the number of periods to complete the structure transformation be 50 year. Afterward, we force both urban population size and manufacturing productivity be constant. The capital eventually will adjust till they reach the steady-state level. We calibrate the sequence of manufacturing productivity A_{mt} to exactly match the population size in the urban area over time. The numerical algorithm can be found in Appendix B.

4 Quantitative Results

We quantitatively evaluate how city-level housing and land frictions affect price dynamics at both national and city-level in this subsection. Given the benchmark parameterization, we follow the procedure described in Appendix B to solve for the equilibrium outcome.

4.1 National Results

In Figure C.1 we plot the model predicted housing and land prices together with the data counterparts during 2007-2013. Overall housing price in 2013 is 1.55 times of that in 2007, while the model predicts a ratio of 1.46, which can rationalize about $1.46/1.55 \approx 94.2$ percent of the change in the data. The model also slightly underpredicts the land price growth in the data. From 2007 to 2013, the model implied land price level has almost doubled, while in the data the land price in 2013 is 2.11 times of that in 2007. In terms of the average annual growth rate, housing and land prices steadily grow at a rate of 7.89 and 14.94 percent in the data, respectively. While the model predicts a growth rate of 6.5 and 12.1 percent, respectively, which can account for 82.4 percent and 81.0 percent of the changes in the data counterpart. To sum up, the model has decently mimicked the data series over time. It seems that for the land prices the model predicts a less dramatic decline between 2007 and 2008, and faster growth between 2011 and 2012.

[9]They include Beijing, Ulanchabu, Kaili, Lianyungang, Ganzhou, Yantai, Zhengzhou, Nanyang, Yichang, Changsha, Zhongshan, Jieyang, and Guilin.

We further explore how housing and land frictions tend to affect both housing and land price levels as well as their growth trends. We perform a counterfactual exercise in which we remove all the frictions by setting them to zero. In Figure C.2, we compare the benchmark prediction with the obtained counterfactual results.[10] When all the frictions are eliminated, housing prices tend to be higher whereas land prices tend to be lower than their benchmark levels. Specifically, they are about xx and xx times of their benchmark counterparts, respectively. Once frictions are removed, we see a steady growth in both housing and land prices as opposed to the decline of land prices in 2007-2008 benchmark results, which suggests the existing frictions seem to dampen the land price growth. In terms of the growth trend, as shown in Table C.9, housing price grows less faster than the benchmark economy. The ratio of housing price in 2013 to 2007 is about $1.283/1.456 \approx 88.1\%$ of the benchmark level, and the average annual growth rate decreases from 6.5 to 4.3 percent. In contrast, land price grows faster in the frictionless economy. This is not surprising. In the data, land tend to become more subsidized over time, and thus when frictions are removed, land are expected to become more expensive over time. Land price ratio is $3.161/1.949 \approx 1.62$ times of that in the benmark economy. The annual growth rate has also increased from 12.1 to 21.5 percent.

To isolate the role of housing and land frictions, we have performed another two sets of counterfactual exercises, in which we either only remove housing or land frictions and simulate the price levels over time accordingly. The results are reported in Figure C.3.[11] The first impression is that housing prices change little when only land frictions are removed. The hints can be found in Equation 5 that land friction does not directly affect the housing price levels. However, the effects still exist through general equilibrium by affecting the population inflow into the city. Overall, as suggested in Table C.9, the price ratio slightly decreases from 1.456 to 1.382, and the average annual growth rate decreases from 6.5 to 5.6 percent. As for the housing price levels, we have shown in Equation (4) that housing prices are increasing with housing frictions. Since housing are subsidized in most cities, and thus housing price slightly increases in the initial years when housing frictions are set to be zero. Housing price eventually becomes lower than the benchmark level because less population

[10] All the price levels in the counterfactual exercise have been renormalized according to the benchmark price level in 2007.

[11] We have similarly renormalized all the price levels according to their benchmark level at 2007.

flow into the cities. In terms of the growth trend, housing price growth slow down when housing frictions are removed. The price ratio and the average growth rate decrease to 1.303 and 4.5 percent, respectively.

Land prices grow much faster when land frictions are removed, and this is still due to the removal of rising land subsidies. Table C.9 suggests that land price ratio and annual growth rate increase from 1.949 to 4.081, and 12.1 to 29.3 percent, respectively. When only housing frictions are removed, land prices become lower because housing sales revenue shrink due to the removal of housing subsidies. The growth trend are also significantly slowed down with a only 1.393 price ratio and 5.7 percent annual growth rate. This seems to suggest the elmination of housing frictions can effectively inhibit land price growth.

The role of capital market frictions We have also briefly examined the role of capital market frictions in driving housing and land prices. The imperfect capital market in our model is captured by the spread between mortage interests and the rate of return to capital, and the latter one is much higher. In the following, we performe a counter-factual exercise in which we double the mortgage interest rates from 5 percent to 10 percent to mimic an improvement in the capital market. The results are reported in Figure C.4. Both housing and land prices become much lower than the benchmark counterpart when mortgage rates are doubled. This is mainly because housing in the city become less affordable with higher mortgage rates as illustrated in Equation 1. This will thus deter the entry of rural migrants into the cities. Prices fall accordingly due to less demand. The growth rate of prices have also become lower due to slower speed of migration into the city.

4.2 City-level Results

We examine city-level results in this section by focusing on the following perspective: First, how different types of frictions affect the spatial distribution of housing and land prices. Second, the model performance in terms of matching housing and land price dynamics in each city, with a particular interests on those tier-1 cities. In Table C.10, we measure how housing and land prices vary across cities for each of the following scenarios: 1) benchmark results, 2) frictionless economy, 3)4) only housing or land frictions are eliminated, 5) we remove the spatial differences in frictions by setting each friction to its average level among all the cities. We use the coefficient of variation to measure the inequality, and report the results year by year.

When all the frictions are removed, the dispersion of both housing and land prices are largely removed in comparison with the benchmark scenario. This suggests the price dispersion are partially driven by the spatial differences of frictions. On average, the CV has decreased by 20 percent for housing prices 45 percent for land prices, respectively. Moreover, both distributions have become more stable over time, with a standard deviation changing from 0.3 to almost zero for housing prices, and from 0.68 to 0.11 for land prices. We have previously argued land friction affects housing prices only through impacting the migration inflow, and thus housing price inequality remains similar to and only slightly lower than the benchmark level when only land frictions are removed. On the contrary, when only housing frictions are removed, housing price inequality are greatly lowered to a level slight above the frictionless outcome. When we eliminate the spatial differences of housing frictions among cities, the dispersion of housing price is the same as the frictionless case. This suggests that it is not the level of housing frictions at each city but the spatial difference of the housing frictions that drive up the housing price disparity. As for land prices, our results suggest that land friction contributes to the land price dispersion. On average, once the land frictions are removed, the CV of land price is about 80 percent of that in benchmark case. In contrast, housing frictions tend to dampen the land price inequality. On average, the CV of land price is about 1.07 times of that in the benchmark case.

We next turn to the comparison between model predicted prices and their data counterparts. In Figure C.5 we map the prediction power of the model in price ratio as well as the average annual price growth rate during 2007-2013 for each city in the sample. The prediction power is simply defined as the ratio of the model implied growth rate to that in the data. A number larger than 1 implies that the model overpredicts. The model underpredicts housing price ratio in 60 cities, and overpredicts land price ratio in 40 cities. On average housing and land price ratio is about 0.72 and 0.76 times of their data counterparts. In terms of the average annual price growth rate, the model predicts higher housing price growth in 14 cities than the data, and overpredicts land price growth for 24 cities. The model implied housing and land price growth rate is about 0.83 and 0.95 times of the benchmark counterparts.

We further explore the role of frictions at city-level in Figure C.6. The counter-factual and benchmark economy each can give rise to a price ratio. We essentially map the ratio of the counterfactual ratio to the benchmark ratio. A number larger than 1 implies price grow faster in the counter than the benchmark economy. When all the frictions are removed, housing price growth in all the cities become slower. The majority of the cities, especially those coastal and large cities, see a higher land price ratio than the benmark economy. This is consistent with the findings in aggregate results. In Figure **??** and Figure **??** we also present results where we either eliminate housing or land frictions. Both housing and land price ratio become lower than the benchmark one in the majority of the cities when housing frictions are removed. When land frictions are removed, land price ratio becomes much higher in the majority of the cities, whereas housing price ratio are still lower in most cities.

5 Conclusion

In this paper, we study how housing and land market frictions affect the growth of housing and land prices as well as the spatial distribution of both prices. We first estimate the city-specific housing and land fricitons among a set of prefectural Chinese cities. We show that both frictions vary systematically across cities and the spatial disparity is persistent over time. We then evaluate the aggregate impacts of the frictions through a dynamic competitive spatial equilibrium framework featured with rural-urban migration. The model can reasonably mimic the price growth in the data counterpart. The counterfactual results suggest that housing(land) prices tend to be higher(lower) than the benchmark once all the frictions are removed, and housing(land) price growth is slower(faster) than the benchmark predictions. Land prices will grow much faster if only land frictions are removed, while housing price growth will slow down if only housing frictions are eliminated.

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Appendix

A Solving Housing Developer's Problem

$$\max_{z_t, I_t} (1-\tau_{ht}) p_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha - q_t z_t (1+\tau_{zt}) - p_{It} I_{ht}$$

FOC gives

$$\begin{aligned}
(1-\tau_{ht}) p_t \gamma A_t^h (z_t - \underline{z}_t)^{\gamma-1} I_{ht}^\alpha &= q_t (1+\tau_{zt}) \\
(1-\tau_{ht}) p_t \alpha A_t^h (z_t - \underline{z}_t)^{\gamma} I_{ht}^{\alpha-1} &= p_{It}
\end{aligned}$$

Take ratio gives:

$$\frac{\gamma}{\alpha} \frac{I_{ht}}{z_t - \underline{z}_t} = \frac{q_t (1+\tau_{zt})}{p_{It}}$$

land market clear:

$$S_t z_t = \ell_t \tag{8}$$

housing market clear:

$$S_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha = N_t^d \tag{9}$$

profit is

$$\pi_t = (1-\alpha-\gamma)(1-\tau_{ht}) p_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha$$

free entry is thus:

$$(1-\alpha-\gamma)(1-\tau_{ht}) p_t A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha = f_t \tag{10}$$

from (1) and (2)

$$\frac{z_t}{A_t^h (z_t - \underline{z}_t)^\gamma I_{ht}^\alpha} = \frac{\ell_t}{N_t^d}$$

assume $\underline{z}_t = \varsigma_t z_t$, then

$$\frac{z_t^{1-\gamma}}{A_t^h (1-\varsigma_t)^\gamma I_{ht}^\alpha} = \frac{\ell_t}{N_t^d}$$

then

$$z_t = \left[\frac{\ell_t A_t^h \left(1-\varsigma_t\right)^{\gamma} I_{ht}^{\alpha}}{N_t^d} \right]^{\frac{1}{1-\gamma}} \tag{11}$$

combine (4) and (1) can solve S_t

$$S_t = \ell_t \left[\frac{\ell_t A_t^h \left(1-\varsigma_t\right)^{\gamma} I_{ht}^{\alpha}}{N_t^d} \right]^{\frac{-1}{1-\gamma}}$$

Moreover, from the first foc, we have

$$\frac{p_t}{q_t} = \frac{\left(1+\tau_{zt}\right)}{\left(1-\tau_{ht}\right) \gamma A_t^h \left(z_t - \underline{z}_t\right)^{\gamma-1} I_{ht}^{\alpha}}$$

Furthermore, we can obtain I_{ht} from

$$I_{ht} = \frac{q_t \left(1+\tau_{zt}\right) \alpha}{p_{It}} \frac{z_t - \underline{z}_t}{\gamma}$$

which can be substituted into (4) to obtain

$$\begin{aligned}
z_t &= \left[\frac{\ell_t A_t^h \left(1-\varsigma_t\right)^{\gamma}}{N_t^d} \right]^{\frac{1}{1-\gamma}} \left(\frac{q_t \left(1+\tau_{zt}\right) \alpha}{p_{It}} \frac{z_t \left(1-\varsigma_t\right)}{\gamma} \right)^{\frac{\alpha}{1-\gamma}} \\
z_t &= \left[\frac{\ell_t A_t^h}{N_t^d} \right]^{\frac{1}{1-\gamma-\alpha}} \left(\frac{q_t \left(1+\tau_{zt}\right)}{p_{It}} \frac{\alpha}{\gamma} \right)^{\frac{\alpha}{1-\gamma-\alpha}} \left(1-\varsigma_t\right)^{\frac{\alpha+\gamma}{1-\gamma-\alpha}}
\end{aligned}$$

substitute into p/q ratio, we have

$$\begin{aligned}
\frac{p_t}{q_t} &= \frac{\left(1+\tau_{zt}\right)}{\left(1-\tau_{ht}\right) \gamma A_t^h \left(z_t - \underline{z}_t\right)^{\gamma-1}} I_{ht}^{-\alpha} \\
&= \frac{\left(1+\tau_{zt}\right)}{\left(1-\tau_{ht}\right) \gamma A_t^h} \left(\frac{q_t \left(1+\tau_{zt}\right)}{p_{It}} \frac{\alpha}{\gamma} \right)^{-\alpha} z_t^{1-\gamma-\alpha} \left(1-\varsigma_t\right)^{1-\gamma-\alpha} \\
&= \frac{\left(1+\tau_{zt}\right)}{\left(1-\tau_{ht}\right) \gamma A_t^h} \left(\frac{q_t \left(1+\tau_{zt}\right)}{p_{It}} \frac{\alpha}{\gamma} \right)^{-\alpha} \left(\left[\frac{\ell_t A_t^h}{N_t^d} \right]^{\frac{1}{1-\gamma-\alpha}} \left(\frac{q_t \left(1+\tau_{zt}\right)}{p_{It}} \frac{\alpha}{\gamma} \right)^{\frac{\alpha}{1-\gamma-\alpha}} \left(1-\varsigma_t\right)^{\frac{\alpha+\gamma}{1-\gamma-\alpha}} \right)^{1-\gamma-\alpha} \left(1-\varsigma_t\right) \\
&= \frac{\left(1+\tau_{zt}\right)}{\left(1-\tau_{ht}\right) \gamma} \frac{\ell_t \left(1-\varsigma_t\right)}{N_t^d}
\end{aligned}$$

rewrite into q/p ratio

$$\frac{q_t}{p_t} = \frac{1-\tau_{ht}}{1+\tau_{zt}} \frac{\gamma N_t^d}{(1-\varsigma_t)\,\ell_t}$$

Finally, free free entry

$$\begin{aligned}
p_t &= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h\,(z_t-\underline{z}_t)^{\gamma}\,I_{ht}^{\alpha}} \\
&= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h\,(1-\varsigma_t)^{\gamma}} z_t^{-\gamma} \left(\frac{q_t\,(1+\tau_{zt})\,\alpha}{p_{It}} \frac{z_t-\underline{z}_t}{\gamma} \right)^{-\alpha} \\
p_t &= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h} z_t^{-\gamma-\alpha} \left(q_t \frac{(1+\tau_{zt})\,\alpha}{p_{It}} \frac{1}{\gamma} \right)^{-\alpha} (1-\varsigma_t)^{-\alpha-\gamma} \\
&= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h} \left(\left[\frac{\ell_t A_t^h}{N_t^d} \right] (1-\varsigma_t)^{\alpha+\gamma} \right)^{\frac{-\gamma-\alpha}{1-\gamma-\alpha}} \left(q_t \frac{(1+\tau_{zt})}{p_{It}} \frac{\alpha}{\gamma} \right)^{-\alpha+\alpha\frac{-\gamma-\alpha}{1-\gamma-\alpha}} (1-\varsigma_t)^{-\alpha-\gamma} \\
&= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h} \left(\left[\frac{\ell_t A_t^h}{N_t^d} \right] (1-\varsigma_t)^{\alpha+\gamma} \right)^{\frac{-\gamma-\alpha}{1-\gamma-\alpha}} \left(\frac{1-\tau_{ht}}{1+\tau_{zt}} \frac{\gamma N_t^d}{(1-\varsigma_t)\,\ell_t} p_t \frac{(1+\tau_{zt})}{p_{It}} \frac{\alpha}{\gamma} \right)^{\frac{-\alpha}{1-\gamma-\alpha}} (1-\varsigma_t) \\
&= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h} \left(\left[\frac{\ell_t A_t^h}{N_t^d} \right] (1-\varsigma_t)^{\alpha+\gamma} \right)^{\frac{-\gamma-\alpha}{1-\gamma-\alpha}} \left(\frac{(1-\tau_{ht})\,\gamma N_t^d}{(1-\varsigma_t)\,\ell_t} \frac{p_t}{p_{It}} \frac{\alpha}{\gamma} \right)^{\frac{-\alpha}{1-\gamma-\alpha}} (1-\varsigma_t)^{-\alpha-\gamma}
\end{aligned}$$

so

$$\begin{aligned}
p_t^{1+\frac{\alpha}{1-\gamma-\alpha}} &= \frac{f_t}{(1-\alpha-\gamma)(1-\tau_{ht})\,A_t^h} \left(\left[\frac{\ell_t A_t^h}{N_t^d} \right] \right)^{\frac{-\gamma-\alpha}{1-\gamma-\alpha}} \left(\frac{(1-\tau_{ht})\,\gamma N_t^d}{(1-\varsigma_t)\,\ell_t} \frac{1}{p_{It}} \frac{\alpha}{\gamma} \right)^{\frac{-\alpha}{1-\gamma-\alpha}} (1-\varsigma_t)^{-\alpha-\gamma+(\alpha+\gamma)\frac{-\gamma-\alpha}{1-\gamma-\alpha}} \\
p_t^{\frac{1-\gamma}{1-\gamma-\alpha}} &= \frac{f_t (A_t^h)^{\frac{-1}{1-\gamma-\alpha}}}{(1-\alpha-\gamma)(1-\tau_{ht})} \left(\left[\frac{N_t^d}{\ell_t} \right] \right)^{\frac{\gamma}{1-\gamma-\alpha}} \left(\frac{\alpha\,(1-\tau_{ht})}{p_{It}} \right)^{\frac{-\alpha}{1-\gamma-\alpha}} (1-\varsigma_t)^{\frac{-\gamma}{1-\gamma-\alpha}}
\end{aligned}$$

B Numerical Algorithm

Calibrating the Manufacturing Productivity

1. For an initial guess of the series of $\{A_{mt}\}$, we first solve backwards for the value function and policy function at each period and capital grid.
2. Given the results from step 1, we then simulate forward for the time series of the capital stock and wage rate from a given initial capital stock.
3. At each period we solve for the current wage rate to match the current urban population size in the data while taking the future price levels as given from step 3.
4. Once the sequence of wage rate is determined, we can update the series of $\{A_{mt}\}$.
5. Repeat step 1-4 till $\{A_{mt}\}$ converges.

Solving the Equilibrium

1. For an in ital guess of wage rates and housing prices over time, we first solve for individual's migration decision to pin down the entire time path of urban population.
2. Given the labor supply in each period obtained from step 1, we can then solve for firm's optimal investment decision at each period, and this also allows to update the wage series.
3. Repeat step 1-2 till wage sequence converges.
4. The resulting urban population series obtained from step 3 also corresponds to the urban housing demand over time, which allows us to update the housing price series.
5. Repeat step 1-4 till housing price series converges.

C Tables and Figures

Table C.1: Summarize Statistics for Estimated Frictions

(a) Housing Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	-0.74	0.93	-1.63	-1.07	-0.52	-0.19	0.06
2008	-1.38	0.97	-2.69	-1.72	-1.18	-0.75	-0.41
2009	-0.82	1.01	-1.91	-1.18	-0.65	-0.10	0.23
2010	-0.74	0.82	-1.70	-1.06	-0.58	-0.12	0.09
2011	-0.97	0.73	-1.83	-1.19	-0.84	-0.48	-0.31
2012	-1.13	1.06	-1.90	-1.48	-0.95	-0.53	-0.26
2013	-1.01	0.84	-1.96	-1.34	-0.85	-0.43	-0.10
Total	-0.97	0.94	-1.92	-1.34	-0.80	-0.37	-0.04

(b) Land Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	-0.03	0.78	-0.68	-0.53	-0.28	0.06	1.19
2008	0.33	1.07	-0.50	-0.34	-0.02	0.55	1.48
2009	-0.27	0.57	-0.78	-0.65	-0.40	-0.02	0.39
2010	-0.51	0.39	-0.87	-0.78	-0.64	-0.35	0.02
2011	-0.50	0.35	-0.80	-0.74	-0.60	-0.39	-0.06
2012	-0.38	0.46	-0.77	-0.68	-0.53	-0.20	0.13
2013	-0.46	0.44	-0.83	-0.75	-0.60	-0.36	0.07
Total	-0.26	0.69	-0.80	-0.69	-0.44	-0.08	0.46

Notes: This table reports the summary statistics for estimated frictions among 93 Chinese prefecture-level cities. The dataset is a combined one on Chinese housing and land markets. Mean is the simple average across all the cities within a given year, and Sd is the standard deviation. P10,P25,P75,P90 refer to the respective percentile within the same year.

Table C.2: Frictions in Tier-1 Cities

(a) Housing Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	0.15	0.15	0.01	0.04	0.11	0.26	0.36
2008	-0.18	0.11	-0.31	-0.25	-0.18	-0.10	-0.04
2009	0.36	0.15	0.15	0.26	0.40	0.46	0.50
2010	0.08	0.01	0.07	0.08	0.09	0.09	0.10
2011	-0.23	0.33	-0.45	-0.43	-0.36	-0.03	0.26
2012	-0.12	0.16	-0.26	-0.25	-0.12	0.02	0.03
2013	0.01	0.08	-0.09	-0.04	0.02	0.06	0.10
Total	0.01	0.25	-0.31	-0.18	0.03	0.13	0.37

(b) Land Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	-0.18	0.40	-0.53	-0.44	-0.30	0.08	0.39
2008	-0.06	0.71	-0.66	-0.50	-0.27	0.39	0.97
2009	-0.58	0.19	-0.82	-0.73	-0.57	-0.43	-0.37
2010	-0.57	0.28	-0.83	-0.76	-0.64	-0.38	-0.17
2011	-0.38	0.52	-0.76	-0.73	-0.57	-0.04	0.38
2012	-0.40	0.27	-0.66	-0.64	-0.41	-0.17	-0.12
2013	-0.62	0.18	-0.76	-0.76	-0.66	-0.48	-0.39
Total	-0.40	0.41	-0.76	-0.67	-0.51	-0.23	0.38

Notes: This table reports the summary statistics for the estimated frictions among the four tier-1 Chinese cities. The dataset is a combined one on Chinese housing and land markets. Mean is the simple average across all the cities within a given year, and Sd is the standard deviation. P10,P25,P75,P90 refer to the respective percentile within the same year.

Table C.3: Frictions in Tier-2 Cities

(a) Housing Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	-0.51	0.67	-1.63	-1.09	-0.31	-0.06	0.13
2008	-1.25	0.83	-2.10	-1.83	-1.16	-0.54	-0.35
2009	-0.61	0.92	-1.79	-0.96	-0.38	0.01	0.26
2010	-0.57	0.85	-1.09	-0.93	-0.44	-0.12	0.22
2011	-0.82	0.50	-1.33	-0.97	-0.70	-0.49	-0.38
2012	-0.83	0.70	-1.52	-1.03	-0.76	-0.41	-0.31
2013	-0.80	0.70	-1.79	-1.02	-0.67	-0.37	-0.07
Total	-0.77	0.77	-1.79	-1.06	-0.64	-0.25	0.01

(b) Land Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	-0.12	0.77	-0.73	-0.63	-0.30	-0.08	1.14
2008	0.02	0.67	-0.50	-0.44	-0.22	0.19	0.63
2009	-0.44	0.40	-0.81	-0.75	-0.51	-0.21	-0.16
2010	-0.59	0.33	-0.88	-0.80	-0.73	-0.39	-0.07
2011	-0.48	0.46	-0.79	-0.76	-0.71	-0.38	-0.06
2012	-0.46	0.24	-0.73	-0.62	-0.53	-0.34	-0.14
2013	-0.55	0.31	-0.83	-0.76	-0.67	-0.38	0.00
Total	-0.37	0.53	-0.79	-0.73	-0.50	-0.22	0.17

Notes: This table reports the summary statistics for the estimated frictions among the 25 tier-2 Chinese cities in our sample. The dataset is a combined one on Chinese housing and land markets. Mean is the simple average across all the cities within a given year, and Sd is the standard deviation. P10,P25,P75,P90 refer to the respective percentile within the same year.

Table C.4: Frictions in Tier-3 Cities

(a) Housing Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	-0.88	0.99	-1.80	-1.09	-0.62	-0.33	-0.15
2008	-1.50	0.99	-2.79	-1.72	-1.25	-0.83	-0.58
2009	-0.97	1.01	-2.19	-1.37	-0.76	-0.31	0.05
2010	-0.85	0.81	-1.94	-1.17	-0.67	-0.24	0.07
2011	-1.07	0.78	-2.25	-1.39	-0.94	-0.51	-0.33
2012	-1.30	1.14	-1.92	-1.57	-1.02	-0.61	-0.34
2013	-1.15	0.86	-2.00	-1.54	-1.00	-0.59	-0.23
Total	-1.10	0.97	-2.19	-1.46	-0.90	-0.51	-0.19

(b) Land Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
2007	0.01	0.81	-0.67	-0.49	-0.25	0.11	1.62
2008	0.46	1.18	-0.50	-0.28	0.01	0.99	2.01
2009	-0.19	0.61	-0.75	-0.61	-0.34	0.08	0.53
2010	-0.47	0.42	-0.86	-0.77	-0.57	-0.32	0.08
2011	-0.51	0.30	-0.83	-0.73	-0.58	-0.39	-0.09
2012	-0.35	0.53	-0.80	-0.71	-0.54	-0.19	0.46
2013	-0.42	0.48	-0.83	-0.73	-0.56	-0.25	0.18
Total	-0.21	0.74	-0.80	-0.67	-0.42	-0.03	0.55

Notes: This table reports the summary statistics for the estimated frictions among the 73 tier-3 Chinese cities in our sample. The dataset is a combined one on Chinese housing and land markets. Mean is the simple average across all the cities within a given year, and Sd is the standard deviation. P10,P25,P75,P90 refer to the respective percentile within the same year.

Table C.5: City size and estimated frictions

	Housing Frictions			Land Frictions		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(GDP)	0.224***	-3.450	0.638	-0.200***	-71.541**	0.245
	(0.066)	(41.556)	(0.410)	(0.041)	(28.436)	(0.326)
Year		-0.069			-0.349***	
		(0.165)			(0.109)	
Ln(GDP) $\times$ Year		0.002			0.036**	
		(0.021)			(0.014)	
N	651	651	651	651	651	651
R-squared	0.049	0.059	0.610	0.073	0.133	0.368
Year FE	No	No	Yes	No	No	Yes
City FE	No	No	Yes	No	No	Yes

Notes: The standard errors clustered at the city level are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01. The table reports regressions of city-level housing and land frictions against GDP between 2007 and 2013. The unit of observation is city-year. The data source for GDP is the city-level statistical yearbooks, and the frictions are based on the estimation procedure outlined in Section 3.2.

Table C.6: The estimated frictions over time

LHS = Frictions	Housing Frictions			Land Frictions		
	(1)	(2)	(3)	(4)	(5)	(6)
Year	-0.016			-0.105***		
	(0.017)			(0.012)		
Year=2008		-0.638***	-0.638***		0.359***	0.359***
		(0.084)	(0.083)		(0.126)	(0.126)
Year=2009		-0.081	-0.081		-0.236***	-0.236***
		(0.066)	(0.066)		(0.089)	(0.089)
Year=2010		0.006	0.006		-0.476***	-0.476***
		(0.074)	(0.074)		(0.075)	(0.075)
Year=2011		-0.230**	-0.230**		-0.464***	-0.464***
		(0.089)	(0.089)		(0.078)	(0.078)
Year=2012		-0.388***	-0.388***		-0.349***	-0.349***
		(0.106)	(0.106)		(0.086)	(0.086)
Year=2013		-0.266***	-0.266***		-0.432***	-0.432***
		(0.091)	(0.091)		(0.082)	(0.082)
N	651	651	651	651	651	651
R-squared	-0.000	0.044	0.609	0.092	0.164	0.370
Year FE	No	Yes	Yes	No	Yes	Yes
City FE	No	No	Yes	No	No	Yes

Notes: The standard errors clustered at the city level are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01. The table reports regressions of city-level frictions against a linear time trend or year dummies. The unit of observation is city-year. The frictions are based on the estimation procedure outlined in Section 3.2.

Table C.7: Migration Probability Rank

	top 5	**bottom 5**
1	Beijing	Zhanjiang City
2	Shanghai	Xiangfan City
3	Chongqing	Beihai City
4	Shenzhen City	Jilin city
5	Chengdu City	Bengbu City

Table C.8: Benchmark Parameterizations

Para.	**Model**	**Para. Value**
β	subject discount factor	0.95
σ	labor share	0.6
$\underline{\epsilon}$	minimum migration cost	69.2
λ	skewness of migration cost distribution	0.16
B	entry fee coefficient	2.17
g_m	productivity growth rate	0.04
η	average housing price growth rate	2.8
g_ς	housing/land price ratio growth rate	0.11

Table C.9: Aggregate Results

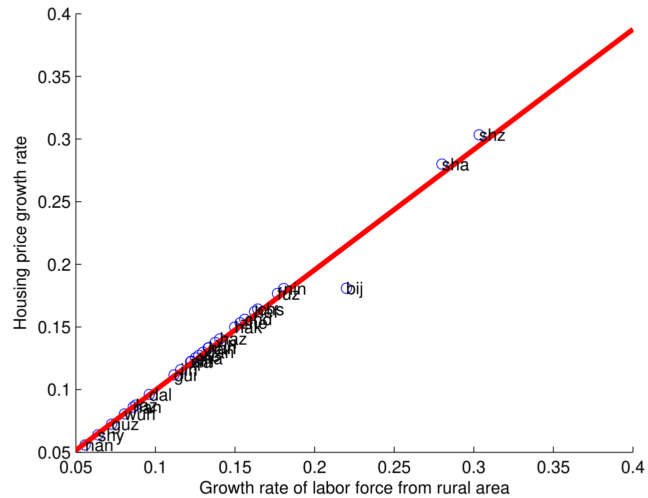
	Bench	Frictionless	No Housing	No Land
Housing Price Ratio	1.456	1.283	1.303	1.382
Land Price Ratio	1.949	3.161	1.393	4.081
Housing Price Growth	0.065	0.043	0.045	0.056
Land Price Growth	0.121	0.215	0.057	0.293

Notes: We present results for the following economy: benchmark economy; frictionless economy; the economy without housing frictions; the economy without land frictions. The results include: the ratio of housing or land prices in 2013 to that in 2007, and the average annual price growth rate.

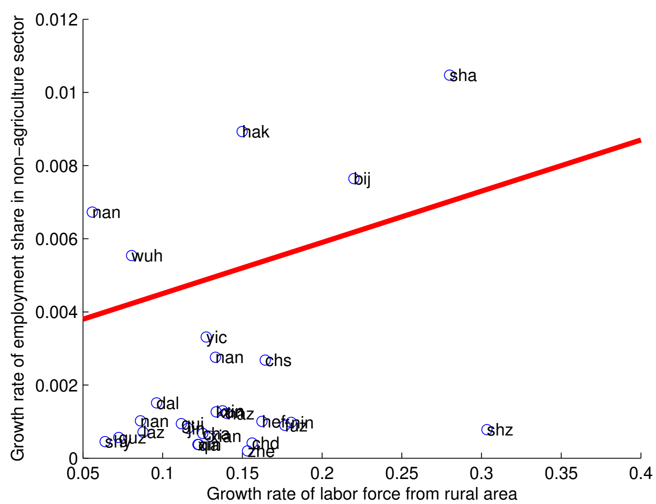
Table C.10: City-level Results

	Benchmark	Frictionless	No Housing Frictions	No Land Frictions	No Spatial Dif
	Housing Price CV				
2007	3.57	2.67	2.89	3.51	2.67
2008	3.43	2.66	2.75	3.26	2.66
2009	3.77	2.66	2.96	3.37	2.66
2010	3.08	2.66	2.93	2.97	2.66
2011	2.93	2.66	2.87	2.85	2.66
2012	3.09	2.66	2.92	3.01	2.66
2013	3.31	2.66	2.83	3.22	2.66
	Land Price CV				
2007	3.76	1.51	5.72	2.26	2.14
2008	2.63	1.38	1.99	2.09	1.84
2009	2.73	1.33	2.69	2.74	10.26
2010	1.82	1.29	2.10	1.58	5.67
2011	2.66	1.26	2.09	1.59	4.30
2012	1.84	1.22	2.19	1.60	4.12
2013	2.08	1.20	2.22	1.93	6.03

Notes: This table reports statistics on both housing and land price dispersion as well as their average levels among the selected sample cities in benchmark and several counterfactual exercises. We measure price inequality using the coefficient of variation. The counterfactual exercises include completely eliminating all the frictions; either eliminating housing or land frictions; eliminating the spatial differences of frictions by setting to their average levels.



(a) Housing Prices



(b) Land Prices

Figure C.1: Migration Pattern in China

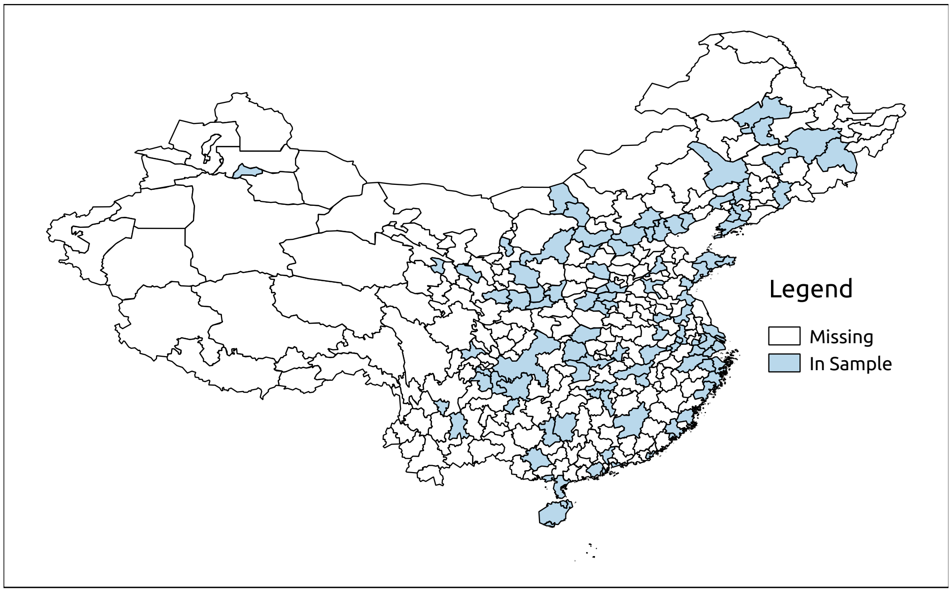
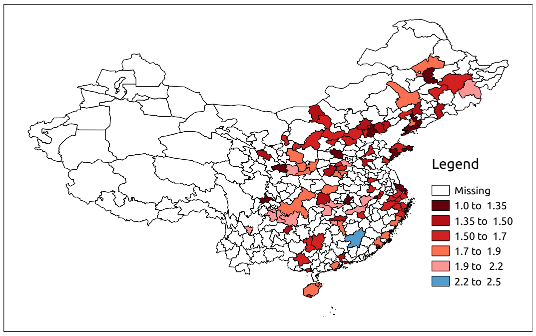
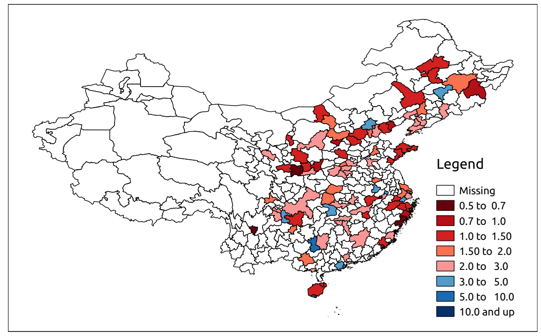


Figure C.2: Selected Sample

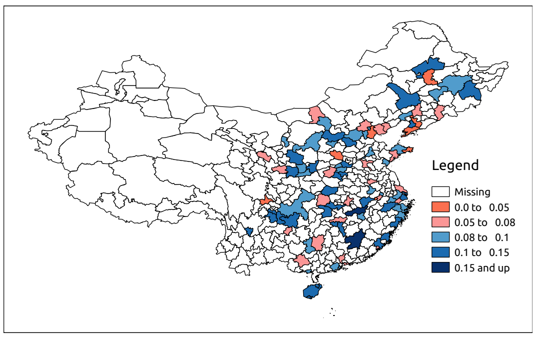
Notes: This graph plots the 93 prefecture-level cities in our sample. All the cities that are included contain the following data information during 2007-2013: (1) Real average price of newly-built housing units; (2) Real average price of residential land parcels; (3) Floor area of newly-built housing units sold; (4) Investment on housing development (exclude land purchase); (5) Residential land sales; (6) Real unit construction cost.



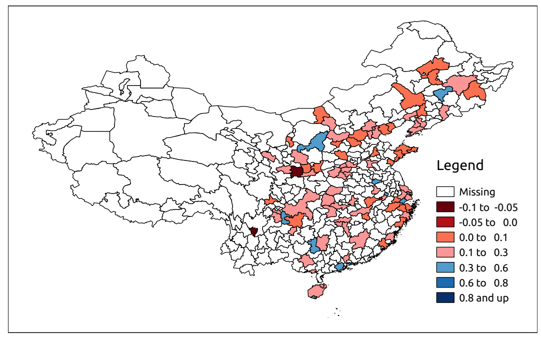
(a) Housing Price Ratio



(b) Land Price Ratio



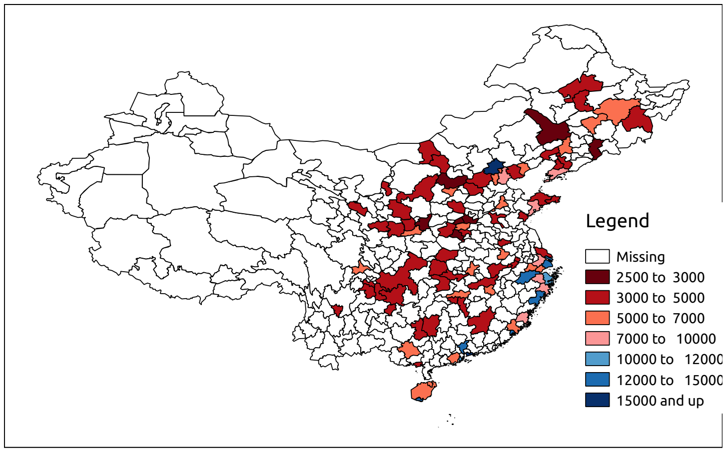
(c) Housing Price Growth



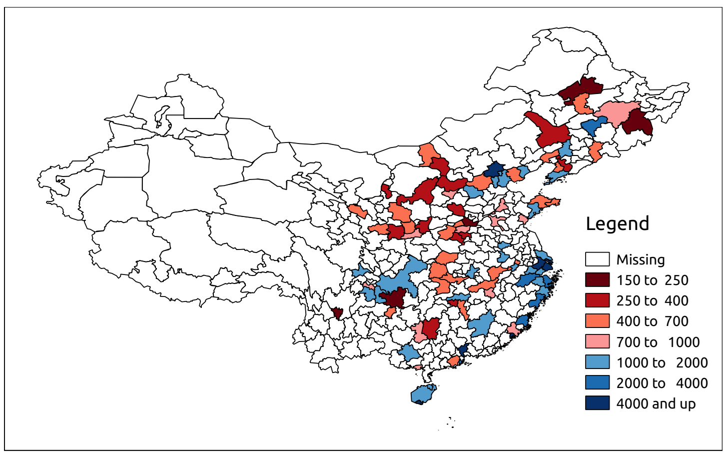
(d) Land Price Growth

Figure C.3: City-level Data

Notes: This table maps some selected statistics on housing and land price growth during 2007-2013 in the data for our selected sample. Price ratio denotes the ratio of price levels in 2013 to 2007. Growth rate is the average annual growth rate during 2007-2013.



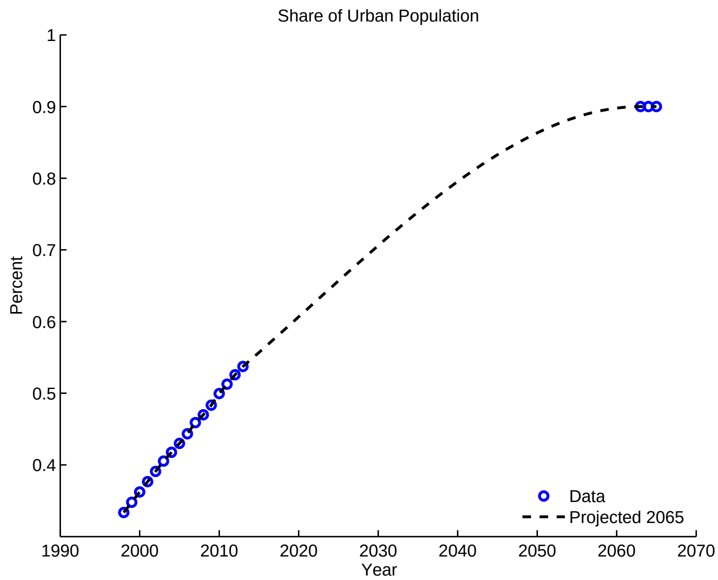
(a) Housing Prices



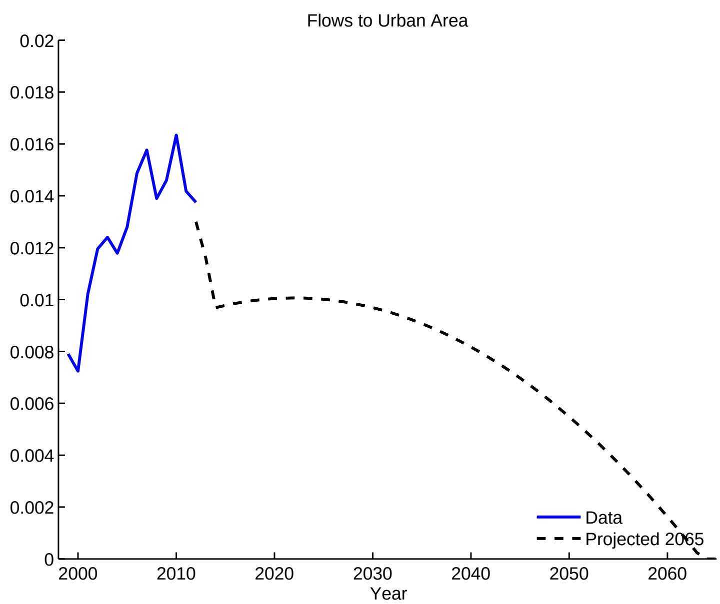
(b) Land Prices

Figure C.4: Price Level in 2013 Data

Notes: This table maps the housing and price levels in 2013 data for our sample.The unit of RMB per square meter measured in 2010 price level.



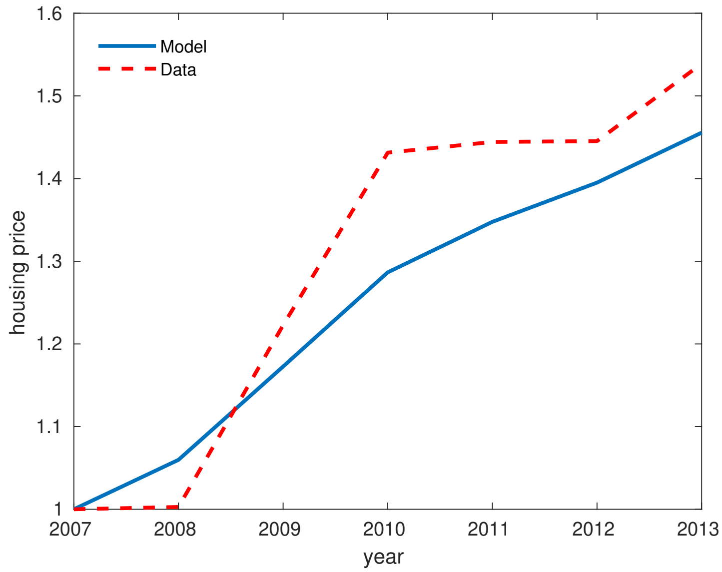
(a) Urban Population



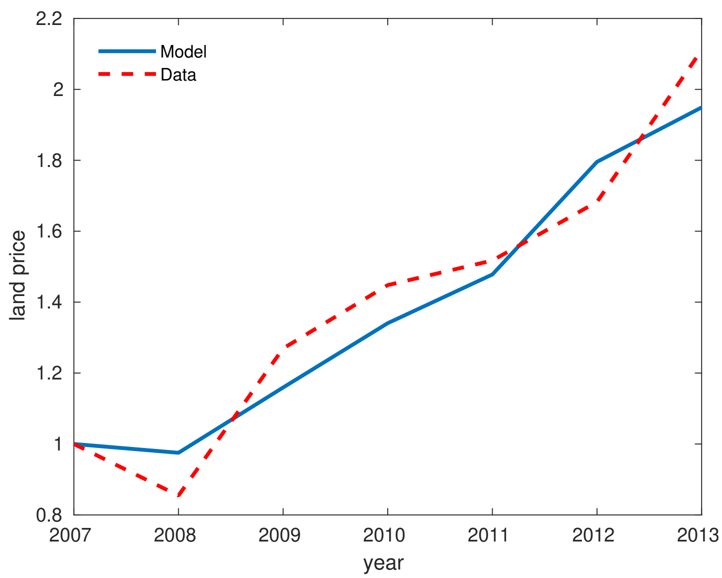
(b) Migration Flow

Figure C.5: Population Projection

Notes: In this figure, we project the urban population trend by assuming that the structural transformation in China will complete year 2063. Specifically, we assume net migration flow into urban area will continue to grow until the year 2020, and afterwards it will steadily decline.



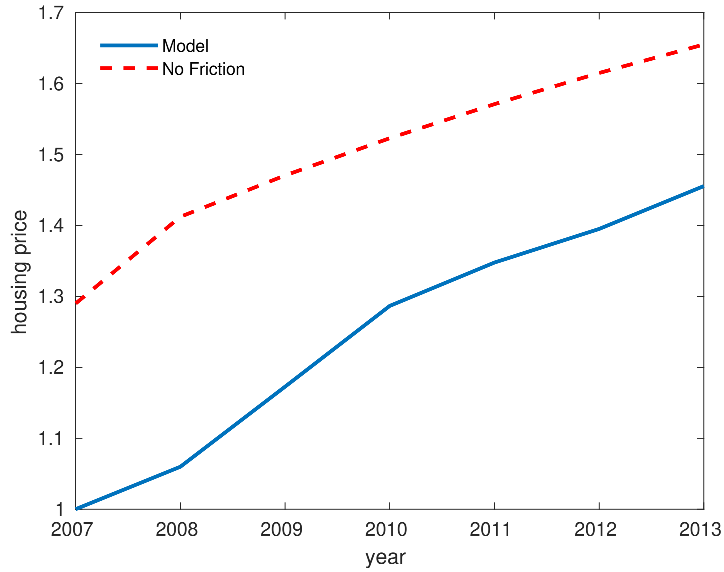
(a) Housing Prices



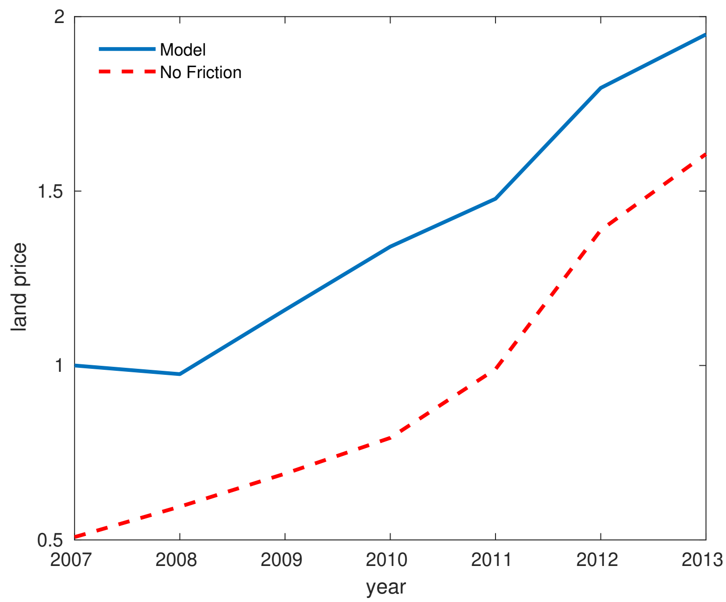
(b) Land Prices

Figure C.1: Model v.s. Data

Notes: This figure plots the model predicted housing and land price levels against their data counterpart during 2007-2013. We have normalized the price level for all the series to be 1 in 2007.



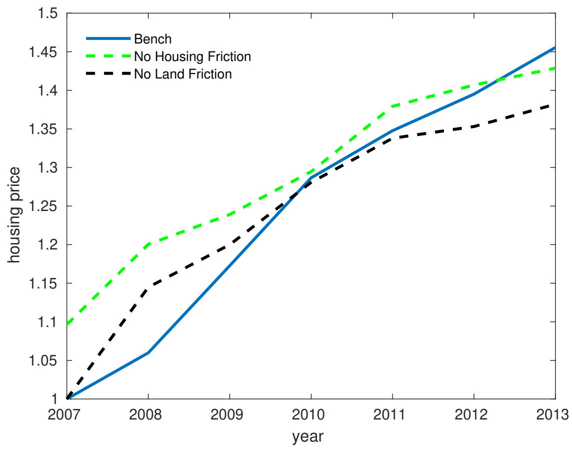
(a) Housing Prices



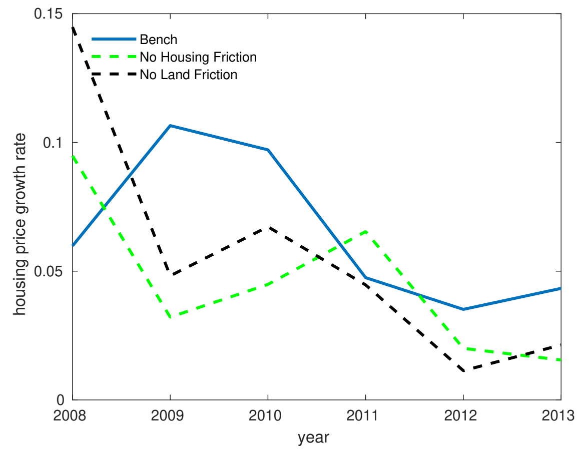
(b) Land Prices

Figure C.2: Model v.s. Frictionless Economy

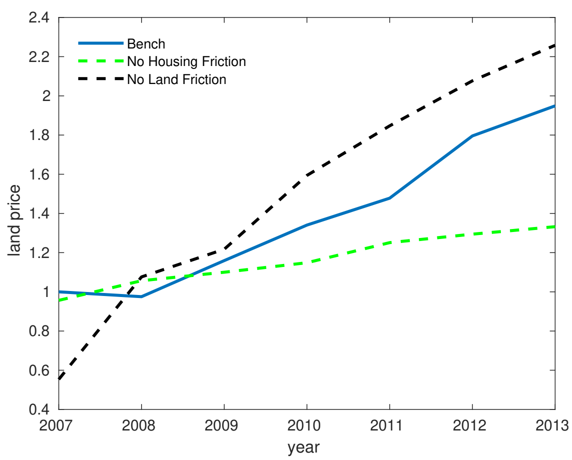
Notes: This figure plots the model predicted housing and land price levels during 2007-2013 against their counterparts in a counterfactual economy where all the frictions are eliminated. We have normalized both housing and land price to be 1 in the benchmark 2007 economy.



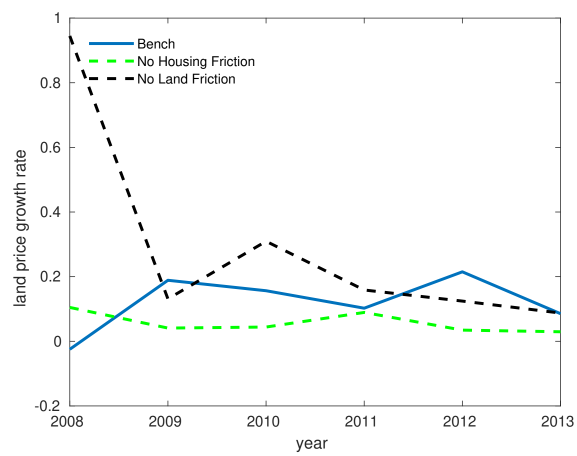
(a) Housing Prices



(b) Housing Prices Growth Rate



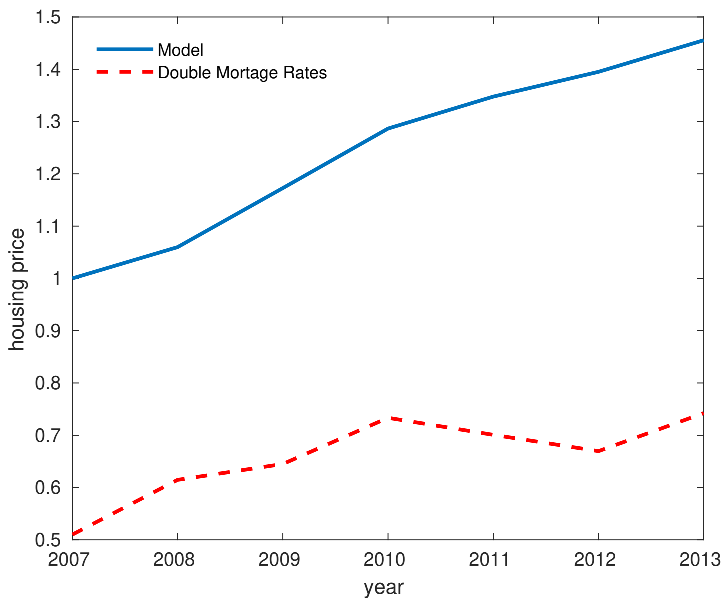
(c) Land Prices



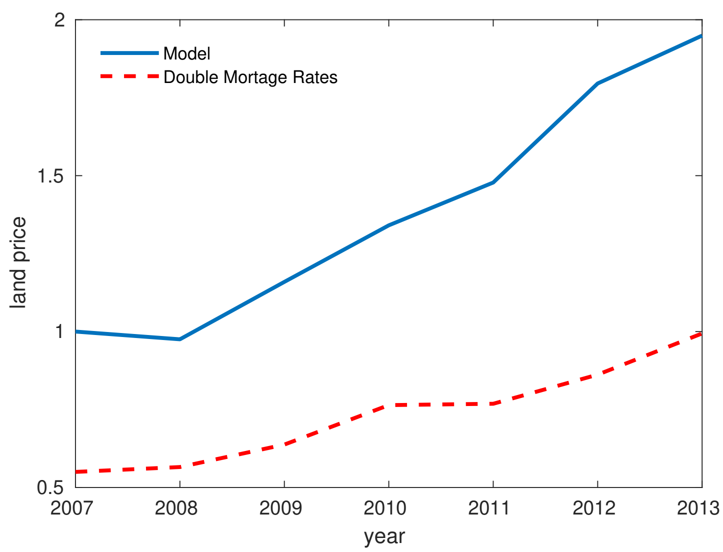
(d) Land Prices Growth Rate

Figure C.3: Decomposition of Frictions

Notes: This figure plots the housing and land price levels as well as their annual growth rate during 2007-2013 in a counterfactual economy where all the frictions are eliminated, or either housing or land frictions are eliminated. We have normalized both housing and land price level to be 1 in the frictionless 2007 economy.



(a) Housing Prices



(b) Land Prices

Figure C.4: Benchmark v.s. Doubled Mortgage Interest Rates

Notes: This figure plots the model predicted housing and land price levels during 2007-2013 against their counterparts in a counterfactual economy where mortgage interest rate are doubled. We have normalized both housing and land price to be 1 in the benchmark 2007 economy.