

Rural-Urban Migration, Structural Change, and Housing Markets in China*

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Abstract

This paper explores the role of structural transformation and the induced rural-urban migration in the recent housing boom in China. This process fosters an ongoing increase in urban housing demand that combined with a relatively inelastic supply (land and entry restrictions) raises housing and land prices. This is analyzed using a multi-sector dynamic general-equilibrium model with rural-urban migration and housing. Our quantitative findings suggest that this process accounts for two-thirds of housing and land price movements in the entire urban area. The performance of the model calibrated to the two largest cities improves substantially, indicating the essentiality of market fundamentals.

Keywords: Migration, structural change, housing boom.

J.E.L. codes: E24, G21, J11, J21, J61, R11, R23, R31

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1. Introduction

Since the implementation of the market reform and open policy in 1978, China has grown into the largest world factory at the turn of the new millennium. The annual growth rate over the past 30 years averaged 8 percent, atop the world. Accompanied by its rapid economic growth, China has witnessed a fast structure transformation, from largely an agricultural society toward modernization. Compared with the speed of structure transformation, its urbanization process has been relatively moderate, with more than half of the population still living in the rural area. Some research has argued that the low rate of urbanization is inconsistent with the observed boom in housing prices.¹

In this paper, we challenge this conventional wisdom by exploring the role of structural transformation played in China's housing boom. We highlight three major channels through which structural change affect housing prices. First, structural transformation increases manufacturing productivity and generates higher incomes in urban areas, thus leading to a greater ability to pay. Second, housing supply is relatively inelastic due to heavily regulated land supply and the market entry of real estate developers. Third, as a consequence of structural transformation, there is a continual rural-urban migration that fosters an ongoing increase in the demand for urban housing. Our view is that structural transformation implies job relocation from agricultural to non-agricultural sectors, and also induces rural to urban migrations where most production takes place.

Our main mechanism is consistent with the data as summarized in Figure 1. In the left panel, we plot the average annual housing price growth rate against the average annual growth rate of the level of migration from rural area in 29 cities from 1998-2007. The positive relationship suggests that housing price grows faster in cities that receive a larger inflow of migrants from rural area. In the right panel, we plot the average annual growth rate of employment share in non-agriculture sector against the average annual growth rate of the level of migration from rural area for the same sample. The positive relationship implies most migrants from the rural area work in the non-agricultural sector in the city. These two observations together are consistent with the idea that when workers migrate from rural to the city, most likely they have to switch from agricultural job to a non-agricultural one. As such, cities offer more non-agricultural jobs can potentially attract more migrants, which in turn can lead to faster housing price growth rates.

To investigate the influence of structural transformation on urban housing development, we consider an economy that is geographically divided into two regions: a rural area producing agriculture goods and a city producing manufactured goods. Continual technological progress drives workers away from the rural agricultural sector to the urban manufacturing sector. When arriving in a city, workers need to purchase houses with a downpayment and a long-term mortgage. Houses are built by real estate developers who need to purchase land and construction permits from the government. The basic framework only considers a single

¹For example, Chen and Wen (2014) explore the existence of housing bubbles.

urban area, but is then generalized to the case of multiple cities. This extension allows to assess the contribution of different migration flows to the change of housing and land price growth rates across cities. More importantly, the evaluation of the contribution of structural transformation for large cities can further allow us to check whether some of these markets might have housing prices not supported by fundamentals.

To disentangle the contributions of various underlying forces (downpayment constraint, the entry fee, the land supply policy, and the productivity of the manufacturing sector), we calibrate the model to mimic the early stages of development in China from 1980 to 2010. The future projected path for the structural transformation through 2100 is based on the U.S. experience from 1950 to 1990. We are particularly interested in the period between 1998 and 2007. Before 1998 China housing market was largely controlled by the government and housing prices were heavily regulated. After 2007 housing prices were severely affected by the global financial tsunami.

The main findings can be summarized as follows. At the national level, the model suggests that the process of structural change accounts for a significant proportion of housing and land price movements, capturing more than $2/3$ of housing prices and of land prices. Productivity (income) is the main driver of house price movements, rationalizing almost half of housing and land price movements. While supply conditions (developers entry and land supply regulations) and access to credit each account for about a quarter of the changes in housing prices, supply conditions alone account for almost $1/2$ of the changes in land prices. In the multi city case, the model is calibrated to match the migration flows to the two largest cities in China (Beijing and Shanghai). The model performance improves substantially when looking at these two cities accounting for $5/6$ of housing price growth and $3/4$ of land price movements. This suggests that market fundamentals captured by structural transformation remain a key driver of housing prices. For both cities, productivity growth is even more important (by 10 percentage points) in explaining the growth of housing prices. While land supply and productivity continued to be important rationalizing the evolution of land prices, their relative contribution is smaller compared to the national level.

2. Literature Review

Since 1978, the Chinese economy has undertaken many political and economic reforms. Afterward, the economy has grown rapidly becoming the second largest in the world. The growth of this economy has been especially important starting from 1992. There is a large literature studying the development of China. For example, Chow (1993) analyzes the path of development of different sectors in the economy. Brandt, Hsieh, Zhu (2008) further documents the process of industrial transformation and role played by institutions and factor allocation barriers. Hsieh and Klenow (2009) highlight that the misallocation of capital and output distortions can result in sizeable losses in productivity in China. Song, Storesletten, and Zilibotti (2011) argue that the elimination of the distortions associated to state-owned enterprises can be responsible for the rapid economic growth after 1992. Zhu (2012) provides

a very extensive summary documenting the various stages of economic development of this economy separating the periods of factor accumulation from the episodes of large increases of total factor productivity.

Ignoring the particular institutional details of China, this paper combines three different strands of literature, structural transformation, rural-urban migration and housing.

The literature of structural transformation goes back to classic works including Rostow (1960) and Kuznets (1966). The more recent renewal of this literature is mostly rooted on the dynamic general equilibrium framework. For example, Laitner (2000) highlights savings as a key driver of modernization, whereas Hansen and Prescott (2001) and Ngai and Pissaridis (2004) emphasize the role of different technology growth rates played in structural change. In Gollin, Parente, Rogerson (2002), the advancement in agriculture productivity is essential for fulfilling subsistence and hence reallocating labor toward the modern sector. Using a nonbalanced growth model, Kongsamut, Rebelo and Xie (2003) illustrates the presence of subsistence consumption of the agricultural good can lead to downward trend in agricultural employment. With agricultural subsistence as an integral part, Casselli and Coleman (2001) study structural transformation and regional convergence in the U.S., while Duarte and Restuccia (2010) investigate the role of such transformation in cross-country differences in labor productivity. Buera and Koboski (2009) examine whether sector-biased technological progress or non-homothetic preferences as a result of agricultural subsistence fits with the data. Buera and Koboski (2012) further elaborate that scale technologies are important forces leading to industrialization. For a comprehensive survey, the reader is referred to a handbook chapter by Herrendorf, Rogerson, Valentinyi (2013).

The pivotal studies on rural-urban migration are Todaro (1969) and Harris and Todaro (1970), where in a static setup such migration is determined based on the tradeoff between higher wage and possible unemployment in urban areas. Using a life-cycle framework, Lucas (2004) highlights a dynamic driver of such migration, the accumulation of human capital and hence on-going rise in wages in cities. More recently, Bond, Riezman and Wang (2013) show that trade liberalization in the capital-intensive import-competing sector can speed up such migration process, leading to faster capital accumulation and economic growth.

In our analysis, the process of structural transformation in the manufacturing sector is the driver of the migration process to the cities. Migration flows increase the demand for residential housing affecting prices. To isolate the contribution of migration flows to house prices, in the model housing demand is only determined by migrants from the rural areas into the cities (extensive margin).² This formalization contrasts with a large literature of user cost models (e.g., Himmelberg, Mayer, and Sinai, 2005) or general equilibrium asset pricing models (e.g., Davis and Heathcote, 2005, and Kahn, 2010) where prices are determined by a representative individual that adjusts the quantity of housing consumed. From the housing supply perspective, the model emphasizes the role of government restrictions in the

²Focusing on the extensive margin allows separating the contribution of structural transformation on the housing market from other considerations.

production of housing units. The case of China is consistent with the findings in the literature that emphasize the role of these artificial restrictions in the determination of house prices (e.g.; Saez, 2007 and Glaeser et al., 2005). The model with multiple cities is consistent with the work of Gyouko et al. (2006) that argue that inelastically supplied land is a key driver of the phenomenon called “super cities”. The analysis is also connected with a literature that explores the drivers of housing boom-bust episodes to financial frictions (e.g.; Burnside, Eichenbaum, and Rebelo, 2011, Landvoigt, Piazzesi, and Schneider, 2011, and Garriga, Manuelli, and Peralta-Alva, 2012.)

3. An Overview of Development in China

This section summarizes the development in China focusing on the processes of structural transformation and urbanization, and the impact on the housing markets. We begin by documenting some stylized facts, and then, discuss the importance of migration policies and the deregulation of housing markets.

3.1. Structural Transformation, Urbanization, and House Prices

The Chinese economy has not completed the process of structural transformation, as can be seen in Figure 2. The sectorial share of employment in agriculture has declined dramatically from almost 70 percent in 1980 to below 40 percent in 2008. An implication of this decline is that the agricultural share in output share has fallen from 30 to 12 percent.

During the same period, the urban employment ratio has increased from 25 to 39 percent. Moreover, the population has continued to flow from the rural to urban areas. As can be seen in Figure 3, the fraction of urban population increased from a low initial level 20% in 1980 to 60% in 2008, and the levels of migration from rural areas to urban areas has ranged between 0.2% to 3.2%, averaging 1.5% per year.

This process of structural transformation and urbanization would naturally have an impact on housing demand and its price. According to the National Bureau of Statistics of China, the aggregate market value of residential housing reached nearly 3.85 trillion RMB in 2009, which is 100 times more than that in 1992. The average residential housing price in 2009 was 4,459 RMB per square meter, compared to 996 RMB per square meter in 1992 (see Figure 4).

3.2. Migration Policies

“The Third Session of the Eleventh Central Committee of the Party” in 1978 is widely believed to be the turning point in the Chinese development path. After this meeting, the Chinese economy gradually transits from a centrally planned economy to a market-oriented one. A key feature of the market economy is the introduction of incentive mechanisms and the reduction of the monopoly power of state-owned enterprises. The encouragement of entrepreneurship stimulates unprecedented technology progress in all sectors. As labor

productivity in the agriculture sector improves, there are surplus rural labor available for urban employment. However, migration across regions is heavily regulated by the household registration system in China.

The household registration system is called “hukou” in Chinese. A hukou is a record of household registration required by law. The system itself is more properly called “huji”, and it has origins in ancient China. A household registration record officially identifies a person as a resident of an area and includes identifying information such as name, parents, spouse, and date of birth. In 1958, the Chinese government officially promulgated the family register system to control the movement of people between urban and rural areas. Individuals were broadly categorized as “rural” or “urban” workers. A worker seeking to move from the country to urban areas to take up non-agricultural work had to apply through the relevant bureaucracies. The number of workers allowed to make such moves was tightly controlled. Migrant workers needed six passes to work in provinces other than their own. People who worked outside their authorized domain or geographical area did not qualify for grain rations, employer-provided housing, or health care. There were controls over education, employment, marriage and so on. The hukou system is widely regarded as an impediment to economic development. China’s accession to the World Trade Organization forced it to reform hukou to liberate the movement of labor for the benefit of the economy. The rural-urban migration history in China can be divided in three stages starting from 1978 into three stages, based upon the central government’s policy toward it.

1. Steady stage (1978-1983): During the early stage after the reform everything was still under probation and the key theme of this subperiod feature a slow progress. Due to the emphasis in agriculture self-sufficiency, most of the migration flows were within rural areas. Among the aggregate population flow of about 14-23 million only 1 million people migrated across provinces. That only accounted for 0.1 percent of the total population. Agriculture productivity advanced during this period, but those workers who left their farm land were mainly absorbed by the local township enterprises. This created a phenomenon called “leave land without leaving home”. Workers left the farm labor force, but still resided in the rural areas.

2. Gradual growth stage(1984-1994): As agriculture productivity continued to increase, more rural workers left the agriculture sector, and local township enterprises could not accommodate these surplus laborers. The “leave land without leaving home” mode requires a breakthrough. As a result, to meet the needs of economic development, policy restrictions towards migrants from rural areas into cities were mitigated. In 1984, the General Office of the State Council published a new document on the settlement of rural migrants in the city, making it easier to migrate to the city. The reform of the household registration system drastically improves the employment opportunities for rural workers. Cities grew as the mode gradually changed to “leave both land and home”. Meanwhile, instead of mainly moving to small towns, as in the early 1980s, rural workers started to move to bigger cities, including megalopolises like Beijing and Shanghai. From 1984 to 1994, rural-urban migration generally

kept a steady pace. The average number of rural migrants moving across provinces increased to 3.2 million per year, which was more than 2.5 percent of the total population.

3. Highly active stage (1995-2000): Population movements in China reached a highly active period from 1995 onwards. Over this period, the total number of rural migrants across provinces grew from 3.5 to 10 million. This is the result of three important policy changes.

- **Southern Trip:** With the world famous speech given by Deng Xiaoping in 1992, Chinese economy development reached its boom stage. The eastern coastal area experienced unprecedented economic growth, and a number of special economic development zones were built, which attracted many foreign enterprises and investment. This growth created more jobs in these cities inducing more workers to leave rural areas.
- **Abandonment of the centrally planned food and housing allocation system:** The central government generally controlled the allocation of food and housing among citizens; workers without a legal permit to live in the city were not able to obtain food and housing even though they could afford them, because there were essentially no markets to trade them. The establishments of markets for basic living necessities like food and housing, greatly facilitated the entry of rural people in the city.
- **Temporary work permits in large cities:** Towards the end of the 1990s, migration accelerated as a result of policies that allow issuing temporary work permits for migrants into large cities. For instance, in 1997 the General Office of the State Council permitted some big cities, such as Shanghai and, Guangzhou, to print “blue household registration cards” or “temporarily permits” for rural workers according to the city’s needs. It is estimated that in Zhejiang province, one of the richest provinces in China, the rural migrant population reached 1.9 million from 1998 to 2001. Some provinces considered the feasibility of abolishing all official restrictions between rural and city by naming everyone a “citizen” with equal treatment under the same set of policies. The salient feature of the rural-urban migration in this period was likely the concentration in the eastern coastal areas, which had faster economic growth and higher wage levels.

3.3. The Development of the Housing Market

Urban housing reform has been a major focus of the economic transformation that started in 1978. The central government has been very cautious in applying new reform policies in the public housing sector and carries out various experiments to commercialize the existing urban public housing. The path of urban housing reforms can be divided into three subperiods which represent distinct housing policies.

1. Probation and experiment stage (1978-1988): In April 1980, Deng Xiaoping made a speech on urban housing. He pointed out specifically that (i) urban residents should be allowed to purchase houses (old or new) and (ii) public housing rents should be adjusted

in accordance with rising construction costs (which encouraged home-buying rather than renting). These policies symbolized a major shift in the long-standing policy toward the public housing system. Following this guideline, experiments were conducted in selected cities between 1980 and 1998 with a focus on reorganizing housing production and promoting sales of public housing to ensure a sufficient return on housing investment. These experiments included encouraging new housing sales for building costs alone, subsidizing public housing sales, and increasing public housing rents steadily each year to promote sales.

Nevertheless, few policies provided incentive for private or other forms of housing investment. In the centrally planned economy, housing investments were provided solely by the state through a redistribution process. During economic reform, the central government adopted policies to decentralize the managerial power and introduced market functions into the economy. Without experiences of the market economy, however, the majority of state-owned enterprises became less competitive than the emerging collective-owned and private enterprises. Consequently, the public housing subsidization from the central government could not keep up with the increasing public housing demand. Although the private sector increased steadily each year, there was not enough incentive for the private sector to move toward urban housing investments because of the risk. Therefore the private investments in housing production were low, and insufficient total investments in urban housing were inevitable.

2. Further urban housing reform (1988-1998): At the beginning of 1988, the central government held the first national housing reform conference in Beijing. It agreed in the conference that housing reform could lead to great economic and social benefits and that a bigger systematic housing reform plan was necessary. The major resolutions of the conference were summarized in a document, which was updated and published in 1991. This document marked a turning point in urban housing reform, from pilot tests and experiments in selected cities to overall implementation in all urban areas. Although there were no significant changes in the overall objectives, this was the first resolution to recognize ownership of private housing that was purchased from the public sector. The purchase of public housing had two options. Paying the market price, the individual had the complete ownership of unit, and paying the “standard price” (subsidized price) only provided partial ownership. This reform conveyed a message that the urban housing sector would eventually rely on market forces rather than central planning.

Although a quasi-urban housing market had been established, most participants in the market at that time were employers, not individual buyers. With different interests and more independent policies, the employers and local governments purchased houses and then provided them to their employees at substantially lower rents than the market rates. Thus, the overwhelming majority of urban residents lived in public housing that was also tied to their employment. As a consequence, there were less incentive for urban residents to purchase the housing units.

3. Current stage of urban housing reform (1998—present): In July 1998, the

new State Council adjusted the housing policy and issued an official document. One major change was the termination of material distribution of housing at the end of 1998, which was completely replaced by monetary distribution. According to the new plan, no newly built units were to be allotted. The new policies symbolized the end of the existing public housing system, with the ultimate goal to fully commercialize the housing market. Nonetheless, the government continued to provide cheap-rent housing for the lowest income households, though, the average floor space area per person could not exceed 60 percent of the average local level. Individuals that do not qualify for these government programs need to purchase or rent houses in the private market.

4. The Model

The benchmark economy is geographically divided into two regions: a city area and a rural area. Later the model is extended to the case of multiple cities. There are two types of goods denoted as manufactured and agricultural goods, respectively. The main difference between the two goods is that they are produced separately at the two regions: the rural area specializes in agriculture goods, and the city produces manufacturing goods. The agents can also be classified into two categories, namely workers (rural or city) and housing developers. Agriculture workers live in rural areas. The rest of the land belongs to the city. To switch from agriculture to manufacturing jobs, workers migrate to the city.

The mass of workers is normalized to be 1. Workers are infinitely-lived and each period they inelastically provide 1 unit of labor. Workers are all identical in performing production. The only heterogeneity among workers stems from the level of dis-utility for them to migrate from rural area to the city. We assume this utility cost ϵ follows some distribution function $F(\epsilon)$. Moving back from the city to rural area is assumed to be costless. To simplify matters, we abstract from the description of how equilibrium interest rates are determined. Instead, we simply assume an exogenous interest rate for mortgage loans $r^* > 0$. We can justify this assumption by considering risk neutral overseas investors, who serve as lenders in our setup.

In the following, we will characterize in details different roles that rural workers, city workers, migrants, government and housing developers play, respectively. The competitive spatial equilibrium is analyzed, and then the model is extended to allow for multiple cities to which rural agents migrate.

4.1. Rural Workers

We assume workers in the rural area are self-employed. There is essentially no housing market in the rural area, therefore houses are not traded, and each rural worker is endowed with 1 unit of house. As in manufacturing goods production, labor is again the only input for agriculture goods. A single unit of labor can produce A_t^f units of agriculture goods. Therefore if there are N_t^f workers staying in the rural area, the total supply of agriculture

goods is:

$$f_t = A_t^f N_t^f \quad (4.1)$$

The population in the rural area is an equilibrium object and its determination is specify later.

Given the agriculture goods price p_t , the income level of a rural worker is $p_t A_t^f$. Workers derive utilities from consumption of manufacturing and agricultural goods. The bundle (x_t^m, x_t^f) defines the amount of manufacturing and agriculture goods consumed by rural workers. The recursive optimization problem for a rural worker at period t can be written as follows:

$$\begin{aligned} V_t^R(\epsilon) = \max u(x_t^f, x_t^m) + \beta \max\{V_{t+1}^R(\epsilon), V_{t+1}^M(\epsilon) - \epsilon\} \\ s.t. \quad p_t x_t^f + x_t^m = p_t A_t^f \end{aligned} \quad (4.2)$$

where $V_t^R(\epsilon)$ denotes the life-time payoffs of rural workers with dis-utility level ϵ starting from period t . The worker derives current utility level $u(x_t^f, x_t^m)$. In next period, $t + 1$, he can choose either to stay in the rural area or move to the city. $V_{t+1}^M(\epsilon)$ represents the life-time payoffs for worker with disutility level ϵ who moves to the city in period $t + 1$, after paying for the utility cost ϵ .

4.2. City Workers

Rural and city workers are assumed to share the same preference towards agriculture and manufactured goods. We assume that housing services are a necessity to live in the city. Workers will gain utility from consuming agriculture and manufacturing goods only when they possess at least 1 unit of house, otherwise, their utility levels are set at negative infinity. Specifically, (c_t^m, c_t^f) denotes the amount of manufacturing and agriculture goods consumed by city workers and h_t denotes the number of houses they own. City worker's instantaneous utility function takes the following form:

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

The utility function above implies each worker is satiated at one housing unit and does not benefit from having more than 1 unit of house. Moreover, farm workers also need at least 1 unit of house. As a result, each farm or manufacturing worker demands 1 unit of house in the equilibrium.

We characterize the optimization problem for workers who have already purchased a house in $\tau < t$ as follows:

$$\begin{aligned} V_t^C(\epsilon, b_\tau) = \max U(c_t^m, c_t^f, h_t) + \beta \max\{V_{t+1}^C(\epsilon, b_\tau), V_{t+1}^R(\epsilon)\} \\ s.t. \quad p_t c_t^f + c_t^m + b_\tau r^* = w_t^m \end{aligned} \quad (4.3)$$

For workers that have already been in the city for more than 1 period, they have two state variables: their utility cost from migration, ϵ , and the mortgage debt they bring over when they purchased the house at time τ , b_τ .

$V_t^C(\epsilon, b_\tau)$ represents life-time payoffs for a worker with dis-utility level ϵ and mortgage debt b_τ . He derives current utility $U(c_t^m, c_t^f, h_t)$, and discounts future payoff at rate β by choosing between continuing staying in the city, $V_{t+1}^C(\epsilon, b_\tau)$, and returning to rural, $V_{t+1}^R(\epsilon)$. The worker spends his wage income w_t^m on agricultural, manufactured goods consumption and mortgage debt repayment, $b_\tau r^*$.

4.3. Migration Decisions

During the initial period τ when a rural worker moves to the city, he must purchase a house at price q_τ . Home purchases are financed with an infinite console mortgage and require a downpayment, which is an exogenous fraction ϕ of the housing price in the moving period τ . In the following periods, the specified repayment is d_τ . The constant d_τ can be derived by equating to the discounted value of all mortgage payments, thus is:

$$(1 - \phi)q_\tau h_\tau = \sum_{t=\tau+1}^{\infty} \frac{d_\tau}{(1 + r^*)^{t-\tau}} \quad (4.4)$$

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

$$d_\tau = (1 - \phi)r^* q_\tau h_\tau \quad (4.5)$$

We impose some condition on ϕ so that the amount of downpayment exceeds the value of mortgage payments each period:

$$\phi > \frac{r^*}{1 + r^*}$$

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

$$\begin{aligned} V_\tau^M(\epsilon) &= \max U(c_\tau^m, c_\tau^f, h_\tau) + \beta \max\{V_{t+1}^C(\epsilon, b_\tau), V_{t+1}^R(\epsilon)\} \\ s.t. \quad &c_\tau^m + p_\tau c_\tau^f + q_\tau h_\tau = w_\tau^m + b_\tau, \\ &b_\tau \leq (1 - \phi)q_\tau h_\tau. \end{aligned} \quad (4.6)$$

The budget constraint during the migration stage includes the expenditure associated with the home downpayment and the purchase of goods. The second equation is the borrowing constraint associated to mortgage finance.³ In the following, we will prove in the case of no

³We ignore the possibility that workers may default on the mortgage debt payment d_t . We can justify this argument by assuming workers are either perfectly committed or the punishment for default is severe. We do not exclude the possibility that a city worker may return to the rural area, but they have to lose their downpayment. Therefore, ideally the situation that a relatively productive worker gives up his job in the city and returns to the rural area happens only when wages from working in the manufacturing sector are too low compared with those in the agriculture sector.

reverse migration, borrowing constraint will always be binding.⁴

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

$$V_\tau^M(\epsilon) - \epsilon \geq V_\tau^R(\epsilon). \quad (4.7)$$

Workers will migrate to the city if and only if the payoffs from migration is greater than staying in the rural area. Evaluating the expression above, it is straightforward to show there exists an ϵ^* that determines the cut-off level of rural workers that migrate to the city any given period.

At the aggregate level, the incremental flow of migrants from the previous period is represented by

$$\Delta F_\tau^* = F(\epsilon_\tau^*) - F(\epsilon_{\tau-1}^*)$$

4.4. Manufacturing Sector

The manufacturing goods market is perfectly competitive. Labor is the only input needed, and the production technology is linear in labor

$$Y_t^m = A_t^m N_t^m \quad (4.8)$$

where A_t^m denotes the labor productivity in the manufacturing sector at period t . The employment level in the city is endogenous and depends on the mobility decisions, $N_t^m = F(\epsilon_t^*)$. The price of manufacturing goods is normalized to be 1, and the optimality conditions imply

$$w_t^m = A_t^m \quad (4.9)$$

4.5. Government

Land is supplied by the government. Each period, the government determines the amount of land that is available for housing developers. The total land area in the city is normalized to be 1. If 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,

$$L_t = \ell_t + L_{t-1}, \quad (4.10)$$

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 individuals in the city, H_{t-1}

$$H_t = H_{t-1} + \Delta F_t^*. \quad (4.11)$$

⁴When there is no reverse migration, borrowing constraint will always be binding if utility function is strictly increasing, weakly concave in the consumption component and $\beta \leq \frac{1}{1+r^*}$.

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

The government not only controls the supply of land, but also charges a fee Ψ_t to housing developers which depends on the permits granted

$$\Psi_t = \psi H_{t-1}, \quad \psi > 0. \quad (4.12)$$

A larger number of permits granted in the past, H_{t-1} , implies a higher fixed construction fee. This captures public concerns about congestion and overcrowding in cities.

4.6. Housing Developers

Each housing developer is endowed with a technology to convert land into houses. The specific production function takes the following form:

$$h_t = Az_t^\alpha, \quad 0 < \alpha < 1 \quad (4.13)$$

The production technology specified above is decreasing return to scale. Each housing developer is assumed to live for only one period, and are replaced by an identical agent. This assumption, based on convenience eliminates the complication arising from land inventories problems. An incumbent developer needs to decide how much land to buy in order to maximizing his operative profit Π_t^d . Upon getting the revenue from selling the houses, developers must pay for the fixed cost to the government.

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

$$\Pi_t^d = \max_{z_t} q_t Az_t^\alpha - v_t z_t, \quad (4.14)$$

q_t is the housing price housing developer can sell at by the end of period t , v_t is the land price that housing developer needs to pay to the government.

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

$$\Pi_t^d = \Psi_t. \quad (4.15)$$

4.7. Competitive Spatial Equilibrium

Next, we formalize the definition of equilibrium in our two region benchmark economy with a rural area and a city.

Equilibrium: Given the government policy parameters $\{\ell_t, \psi\}_{t=0}^\infty$ and the initial city housing stock H_0 , an equilibrium is a list of prices $\{p_t, q_t, w_t^m, v_t\}_{t=0}^\infty$ for agriculture goods, new housing and land; a migration cutoff value $\{\epsilon_t^*\}_{t=0}^\infty$; an employment vector $\{N_t^m, N_t^f, M_t\}_{t=0}^\infty$ in the manufacturing, agriculture, and housing sectors, respectively; and a list of quantities $\{z_t, x_t^f, x_t^m, c_t^f, c_t^m\}_{t=0}^\infty$ that describes new houses built and, worker consumption in the farm

sector and in cities, with the following properties:

1. Given the price sequence, workers maximize their lifetime utility and housing developers maximize their current period's profit.
2. The cutoff of mobility cost ϵ_t^* is determined by

$$V_t^M(\epsilon_t^*) - \epsilon_t^* = V_t^R(\epsilon_t^*). \quad (4.16)$$

3. The number of housing developers is determined by the free entry condition

$$\Pi_t^d = \Psi_t \quad (4.17)$$

4. The land market clears:

$$M_t z_t = \ell_t. \quad (4.18)$$

5. The housing market clears:

$$M_t A z_t^\alpha = \Delta F_t^*. \quad (4.19)$$

6. The manufacturing goods market clears:

$$\sum_{\tau=1}^t \int_{\epsilon_{\tau-1}^*}^{\epsilon_\tau^*} c_\tau^m(\epsilon) dF + \int_0^{\epsilon_0^*} c_0^m(\epsilon) dF + x_t^m [1 - F(\epsilon_t^*)] = A_t^m F(\epsilon_t^*) \quad (4.20)$$

7. The agriculture goods

$$\sum_{\tau=1}^t \int_{\epsilon_{\tau-1}^*}^{\epsilon_\tau^*} c_\tau^f(\epsilon) dF + \int_0^{\epsilon_0^*} c_0^f(\epsilon) dF + x_t^f [1 - F(\epsilon_t^*)] = A_t^f (1 - F(\epsilon_t^*)) \quad (4.21)$$

4.8. The Case with Multiple Cities

The model in the previous section restricts the analysis to a single urban area. The model can simply be extended to the case of multiple cities. Suppose there are $I > 1$ cities in the urban area. All the cities are identical in producing manufacturing goods. The only difference across cities contain the following two aspects: (i) Land supply exogenously controlled by the government, $\{\ell_i\}_{i=1}^I$, (ii) The relative productivity in manufacturing sector, $\{A_{i,t}^m\}_{i=1}^I$.

If a rural worker decides to move to the city, he may end up in any one of the I cities in the urban area. The probability that a rural worker will be assigned to city i is denoted to be π_i , where $\sum_{i=1}^I \pi_i = 1$. We furthermore assume that there is no labor mobility across cities. Therefore, once a rural worker is assigned to city i , his location choice afterwards only includes either continue to stay in city i or move back to rural. For a worker of type ϵ , the utility cost of migrating from rural to any of the I cities will be ϵ . Therefore, a worker of

type ϵ will migrate to the city in period t if and only if the following holds:

$$V_t^M(\epsilon) - \epsilon \geq V_t^R(\epsilon)$$

Similar as in the previous analysis, $V_t^M(\epsilon)$ represents the value function for a migrant of type ϵ in period t . It equals to the expected payoff from living in any one of the I cities:

$$V_t^M(\epsilon) = \sum_i \pi_i V_{i,t}^M(\epsilon), \pi_i \geq 0$$

$V_{i,t}^M(\epsilon)$ denotes the value function for a worker of type ϵ who migrates to city i in period t . $V_{i,t}^M(\epsilon)$ takes similar form as the case of one-city: workers maximize current utility out of their current income, which contains both wage income and the amount of borrowing, subject to certain borrowing constraint. Next period workers compare the payoff from moving back to rural to the payoff of continuing to stay in the city i .

$$\begin{aligned} V_{i,t}^M(\epsilon) = \max & U(c_{i,t}^m, c_{i,t}^f, h_{i,t}) + \beta \max\{V_{i,t+1}^C(\epsilon, b_{i,t}), V_{t+1}^R(\epsilon)\} \\ \text{s.t.} \quad & c_{i,t}^m + p_t c_{i,t}^f + q_{i,t} h_{i,t} = w_{i,t}^m + b_{i,t}, \\ & b_{i,t} \leq (1 - \phi) q_{i,t} h_{i,t}. \end{aligned} \quad (4.22)$$

The expression of $V_t^R(\epsilon)$ will be exactly the same as the case of one-city. $V_{i,t+1}^C(\epsilon, b_{i,t})$ will also take very similar form as before. We omit the description here. In each period $t > 0$, there exists a cut-off ϵ_t^* , below which workers will be living in the urban area. ϵ_t^* can be pinned down from the following indifference condition:

$$V_t^M(\epsilon_t^*) - \epsilon_t^* = V_t^R(\epsilon_t^*)$$

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 the same rule. Entry fee collected by city i in period t positively depends on the existing housing stock in city i : $\Psi_{i,t} = \psi H_{i,t-1}$, where $\psi > 0$. Therefore the number of housing developers in each city, $M_{i,t}$, will be determined by the following free-entry condition:

$$\Pi_{i,t}^d = \Psi_{i,t}$$

Housing and land market will be clearing in each city, subject to the exogenous land supply controlled by the government in each city. The market clearing conditions at city i can be derived as follows:

$$\begin{aligned} M_{i,t} z_{i,t} &= \ell_{i,t} \\ M_{i,t} A z_{i,t}^\alpha &= \Delta F_{i,t}^* \end{aligned}$$

Similar to the previous analysis, housing price, land price and the number of housing devel-

opers can be explicitly solved as follows:

$$q_{i,t} = \frac{\psi F(\epsilon_{t-1}^*) \pi_i}{(1-\alpha)A} \left[\frac{[F(\epsilon_t^*) - F(\epsilon_{t-1}^*)] \pi_i}{A \ell_{i,t}} \right]^{\frac{\alpha}{1-\alpha}}$$

$$v_{i,t} = \frac{\alpha [F(\epsilon_t^*) - F(\epsilon_{t-1}^*)] \pi_i}{\ell_{i,t}} q_{i,t}$$

$$M_{i,t} = \left[\frac{[F(\epsilon_t^*) - F(\epsilon_{t-1}^*)] \pi_i}{A \ell_{i,t}^\alpha} \right]^{\frac{1}{1-\alpha}}$$

Since manufacturing goods produced in each city are identical, thus manufacturing goods market will clear at the national level:

$$\sum_{i=1}^I A_{i,t}^m \pi_i [F(\epsilon_t^*) - F(\epsilon_{t-1}^*)] = \sum_{i=1}^I \sum_{\tau=1}^t [F(\epsilon_\tau^*) - F(\epsilon_{\tau-1}^*)] \pi_i c_{i,\tau}^m + \sum_{i=1}^I F(\epsilon_0^*) \pi_i c_{i,0}^m + x_t^m [1 - F(\epsilon_t^*)]$$

5. Quantitative Analysis

The objective of the quantitative analysis is to evaluate the role of structural transformation in the housing boom of China. To that end, we first apply the U.S. experience to project the path along which China will complete the structural change; we then calibrate the model so that the simulated economy can mimic some stylized facts in the early stages of development in China. We compare the model prediction with data to assess how much housing price growth can be rationalized by the model. We also perform some counter-factual exercises to explore the role of financial frictions, land policy etc. in housing price growth. Finally, we extend the quantitative analysis to the multiple-city case, and this enables us to evaluate different contributions structural change might make to housing prices growth in various cities.

5.1. Projection of the Chinese Population and Land Distribution

The following table lists the fraction of rural population in the U.S. starting from 1840 to 2000. There were almost 90 percent of total population in the rural area in 1840, and this percentage has steadily declined to about 3 percent in 1990, and has remained to be 3 percent afterwards. Since the share of rural population is a main indicator of the progress of structural transformation, we consider U.S. has completed its structural transformation in 1990. In 2010, there were still almost half of the population living in the rural area of China. In order to project the path along which China completes its structural change, we apply the relevant experiences in the U.S.. Our algorithm is simply as follows: In 1980, the fraction of rural population in China is nearly 70 percent, and it was 1870 when rural population in the U.S. attained similar level. It took the U.S. 120 years (from 1870 to 1990) to complete the structural transformation. We assume that it will also take China 120 years to finish

the process. Therefore, structural transformation in China will be completed in 2100 (from 1980 to 2100). Table 5 summarizes the projected path for the structural change.⁵

We extrapolate the series on the fraction of rural population till 2100, based upon currently available data. The following graph suggests that when structural transformation completes in China in 2100, the fraction of rural workers will remain to be 8 percent, which we find to be a reasonable number, given the anticipation that labor share in China will be higher than the U.S. Moreover, according to World bank development report, a country is considered to be industrialized if the share of employment in agriculture sector has declined to below 18 percent, and China has exceeded this critical value in 2100.

The total land area in China is 9600,000 square kilometers, where urban area takes about 183618 square kilometers. The floor space of commercialized residential building either under construction or completed is plot in the following graph. Suppose China maintains a constant average floor area ratio overtime, then we can derive the total land area developed for residential use. We also extrapolate future sequence of the ratio of residential land area to total urban land area till 2100 based upon currently available data.

5.2. Calibration of the Chinese Economy

Worker's utility function over agricultural and manufacturing goods takes CES form, where the elasticity of substitution between agricultural and manufacturing goods is given as $1/(\rho - 1)$:

$$u(c_t^m, c_t^f) = [\theta(c_t^m)^\rho + (1 - \theta)(c_t^f)^\rho]^{\frac{1}{\rho}}$$

Workers' disutility level from migration is assumed to follow Pareto distribution with the support on interval $[1, \infty)$:

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

Each period in the model corresponds to 1 year, so we set the subjective discount rate, β , to be 0.95, which is consistent with the tradition in the literature. Annual interest rate, r^* , is taken to be 4 percent. The downpayment ratio ϕ denotes the fraction of the house value that the worker must pay in advance. It is set to be 0.3. We will perform sensitivity analyses in later sections with respect to different types of distribution functions, interest rates, and downpayment ratios to check the robustness of our results. We normalize productivity in agriculture sector A_t^f to be 1. Table 1 summarizes the set of predetermined parameters.

For the remaining set of parameters: $\theta, \rho, \alpha, \psi, \lambda$, and $\{l_t, A_t^m\}$, we calibrate them to match some stylized facts in the early-stage development of China from 1980-2010. These parameters are determined to match six targets: 1) fraction of workers in the city, 2) decline price of manufactured to agricultural goods, 3) decline share of expenditure on agriculture

⁵Note that there may exist more optimistic projections on the progress of structural transformation in China with a much faster transition speed compared with U.S.. The conjecture above is just served as a starting point, later we will perform various exercises with some more optimistic or pessimistic projected paths.

goods, 4) ratio of dis-utility to life-time payoff from living in the city, 5) share of land in housing value, and 6) ratio of entry fee to sales revenue. Given the projected population distribution path between rural and urban area, the computation algorithm is briefly described as follows: according to the definition of the steady-state equilibrium, both relative productivity in manufacturing sector and population distribution will remain constant in the steady state.

Parameters (θ, ρ) govern workers' preferences towards agricultural and manufacturing goods. θ is chosen to match the decline rate of relative price of manufactured to agricultural goods in China from 1980 to 2010. The elasticity of substitution parameter, ρ , is picked to match the average speed of decline of the expenditure share on agriculture goods. α measures of the mark-up of the housing developers. The value of α can be obtained by matching the ratio of land value to the house value.

Over the period 1980-2009 the migration flow from the rural area and the fraction of urban population are summarized in Figure 6. During these three decades the level of migration from rural areas to urban areas has averaged about 1.5% per year. Population flows of this size are responsible for the increased fraction of urban population from a low initial level around 20% in 1980 to over 50% in 2010. Is it this structural transformation induced migration responsible for the increasing housing and land prices?

The right panel of Figure 6 enables to compute the relative manufacturing productivity $\{A_t^m\}_{t=1980}^{2099}$ by matching the fraction of urban population. The terminal condition imposed in the long-run level of productivity, A_{2100}^m , is the hypothetical steady state matching the U.S. level of urbanization that will be achieved in 120 periods.⁶ More explicitly the price of agricultural goods, p_t , can be solved as a function of the relative manufacturing productivity, A_t^m , from the agricultural goods market clearing condition. Each A_t^m then can be pinned down from the indifference condition in each period. Figure 7 summarizes the implied path of productivity for the period 1981-2009. The implied sequence for $\{A_t^m\}_{t=1980}^{2099}$ increases from 4.59 to 11.77 showing that labor productivity in the manufacturing sector is always higher than the agricultural sector.

Once the productivity parameters are determined, the values for λ , ψ , and H_{-1} can then be solved. Specifically, the parameter ψ is calibrated so that the ratio of entry fee to housing developer's sales revenue is 0.1, whereas λ is computed as the average migration costs equal to 10 percent of the value of living in the city. The initial entry fee H_{-1} is derived by normalizing the initial house price to be one. The calibration results are reported in Table 2.

5.3. Quantitative Results: National Benchmark

The main quantitative analysis focuses on the model ability to generate movements in housing and land prices. The model generates predictions for the variables every single year that

⁶We explore the sensitivity of the results to different but plausible time horizons of convergence (e.g., 60 years). The main quantitative results of the paper are not affected.

can then be compared with the actual data. Table 3 reports the average growth rate of predicted prices and aggregate output compared to the actual data for the period 1992 and 2007. The model predicts the evolution of these variables well in terms of the trend, but it is also useful to examine the performance of the model along the entire dynamic paths. The average prediction for each variable is summarized in the last column of the table. The model can predict about 67.1 percent of housing price, 68.4 percent of land price movements, and 80.0 percent of aggregate output movements. In the model, output growth is driven by changes in productivity of the manufacturing sector and labor relocation. Other drivers of economic growth that are not correlated with the previous factors are responsible for the gap between the predictions and the data. Overall, fundamental factors, such as structure transformation and supply restrictions, can indeed account for more than two thirds of the movements in these prices.

The evolution of the predicted prices are depicted in Figure 8 in conjunction with the data counterpart where the initial values of each series have been normalized to one. A deeper look at the figures suggests that the housing price data behave differently over three subperiods. In the period of 1992-1996, housing prices grew fast with average growth rate of 9.4 percent annually. During this period the housing market was still highly regulated and controlled by the government but qualified rural labor was allowed to move to the city. The model captures 70.9 percent of this initial growth (low cost of construction but wages in the city are not very high). The period 1997-2002 was characterized by a significant slowdown in housing prices with annual growth rate of 3.2 percent. This is consistent with Asian financial crisis in 1997, layoff of SOE employees over 1999-2002, and the burst of dot-com bubble in 2001. Because we do not model the financial crisis or SOE layoffs, our model explains less of the housing price movements (65.6%). In the last period of 2003-2007 the housing price was skyrocketed with annual growth rate of 15.1 percent. This is consistent with fast economic growth and further de-regulation of migration policy and financial sector, in conjunction with the government's control on urban land and housing permits. During this sub-period, the model captures the housing price hike quite well. However, due to our under-prediction in the second sub-period, the model can only explain 65.1 percent of housing price movements.

In the data, the pattern of land price movements is somewhat different from housing price. Land price grows drastically from 1998 to 2005 at an annual average of 23.3 percent due to the marketization of housing, but significantly slows down to a 5.4 percent average growth rate from 2005 to 2007. A large fraction of local government's fiscal revenue comes from land sales. As a result, local governments tends to sell land at a price as high as possible with limited supply. To prevent this, the central government in China implemented a series of policies, including the "Law of the Peoples Republic of China on Land Contract in Rural Areas" enacted on January 1, 2003. This eventually slowed down the growth of land prices. In the model, the predictive power during the first sub-period is higher (71.9% vs. 65.7%). This fact could point out a decreasing importance of land supply restrictions in the later part of the sample.

The model can be used to understand the relative importance of the different driving

forces of housing prices and land prices during this time period. This can be done decomposing the relative contribution of the various factors (downpayment constraint, the entry fee, the land supply policy, and the productivity of the manufacturing sector) relative to the benchmark model where everything changes. The decomposition is disciplined maintaining the calibrated parameters to the benchmark values and changing one factor at a time. More specifically, the decomposition considers the following counterfactuals for each factor.

- Entry Fee** The government revenue associated to the entry fee from land developers depends positively on the current population size in the city. A higher value of ψ implies a higher entry fee and less developers. The benchmark value in the calibration is 3. In the counterfactual analysis, the value of ψ_t varies each period so that the government revenue remains constant as in period 0. When the population in the city grows, the computed value of ψ_t should decrease over time. This induces the entry of housing developers and more supply. This leads to a lower housing price and a higher level of migrants. By comparing the counterfactual price with the benchmark price, it is possible to compute the relative contribution of entry fees. Similar exercise can be done for land prices, and migration flows. In the counterfactual exercise the results suggest the annual housing price growth rate would have been 7.0 percent instead of 8.6 percent in the benchmark case, and the average fraction of population in the city 43.0 percent instead of 41.5 percent.
- Land policy:** In this counterfactual experiment, the flow of land supplied by the government to the market is fixed at the initial high level, $\ell_t = \ell_0$ for all t . The relative increase in land supply results generates a right shift in housing supply, leading to a decrease in housing prices and an increase the number of migrants. In this case, the housing price grows rate is 7.6 percent and the average fraction of population in the city is 42.7 percent.
- Downpayment ratio** Parameter ϕ denotes the fraction of the housing value that the migrants need to pay the first period he moves to the city. The benchmark calibration consider a value of $\phi = 0.3$. The counterfactual considers no mortgages financing ($\phi = 1$). The elimination of housing finance should drive the demand and hence the price of housing down. In this exercise, the annualized growth in housing prices and the average fraction of population are lower than in the benchmark with values of 5.8 percent and 39.4 percent respectively.
- Productivity** Productivity acts as the residual in the decomposition exercise. That is all the unexplained part in the benchmark result is due to productivity growth.

The results of the decomposition are summarized in Table 4. The numbers in the table represent the percentage of the increase of each indicator due to a single change in each driving force. For example, in the case of land supply controls the decomposition compares the benchmark with an economy that has an increased availability of land as in the initial

years. The increased availability of land leads to drop in housing price and rise in the population in the city. Thus the tighten land supply policy in the benchmark case contributes to 11 percent of housing price growth in the period 1992-2007, and -11 percent of migration growth over the same period.

Overall, the model suggests that productivity is the most important factor for increases in both housing prices (46.1%) and migration (114.3%). Land supply restrictions and productivity are both crucial for understanding the dynamics of land prices (32.4% and 46.3% respectively). While downpayment explains for about one quarter of housing price movements, its contributions to land prices and migration are modest (at 6 and 10 percent, respectively). Finally, the contributions of developer entry restrictions to all three indicators are all below 20 percent in absolute value.

Looking into more details of the sub-periods, the supply factors (land supply and developer entry restrictions) become more important for housing prices in the third sub-period, which is due to tightened regulations. During the same time, down-payment requirements also becomes more important when homes become extremely expensive. Turning into land prices: land supply and productivity together account for above 75 percent, but the relative contribution of productivity becomes more important in the later sub-period. To explain migration flows, supply factors become more important over time. Their contributions account for 45 percent in the last sub-period, to discourage migration flows. Yet this negative force is outweighed by productivity growth.

5.4. Quantitative Results: Multiple-City Model

The multi city model studies the dynamics of urbanization and housing and land prices at the city level. Figure 9 suggests that the size of migration flows could be responsible for the rapid increase in housing prices in many of the cities in China, but the extend to this increase not only depends on the migration flows but different housing supply restrictions across cities. For better illustration, the analysis is restricted to the two largest cities in China: Beijing and Shanghai. These two cities account for 8 percent of the entire urban population in 20???. In the analysis there is going to be a third city that encompasses the rest of the cities in China. Figure 9 displays the population trend of these three cities. The data suggests that Shanghai and Beijing outgrow other cities with their population growing at rates 3%.⁷ By contrast, rural population declines at rate 1.67 percent annually.

Rapid population growth naturally led to housing booms in these two major cities. Figure 10 summarizes the evolution of housing and land prices. One can see that housing price level in both Beijing and Shanghai are always above the national average level. Housing price in Beijing had an initial period of rapid growth in the late 1990s, but remained stable until 2005; by contrast housing price in Shanghai has been continuously growing with a more rapid trend starting in 2004. Land prices grew at a comparable rate across these two cities,

⁷The only city growing faster than Beijing and Shanghai is Shenzhen, but its size is substantially smaller than the two largest cities.

but at a much faster rate in 2005.

The model with multiple cities has to be consistent not only with the rural to urban migration but also with the city population. In the multiple-city scenario, the general parameters are maintained from the single city model with the exception of the exogenous probability of migrating to city i from the rural, π_i ; the relative manufacturing productivity in city i , $\{A_{i,t}\}$; and the total land area for residential use in city i , $\{L_{i,t}\}$. When there are $I > 1$ cities in the urban area, share of 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.

$$n_{i,t} = \frac{N_{i,t}}{\sum_{i=1}^I N_{i,t} + N_t^R}$$

When total population is normalized to be 1, growth rate of $n_{i,t}$ can be shown to be equivalent to the growth rate of $N_{i,t}$:

$$\frac{\Delta N_{i,t}}{N_{i,t}} = \frac{\Delta n_{i,t}}{n_{i,t}}$$

Since each period a fraction π_i of the migrants will move to city i from the rural, and this implies:

$$\Delta N_{i,t} = -\pi_i N_t^R$$

Therefore, the growth rate of $n_{i,t}$ can be represented as follows:

$$\frac{\Delta n_{i,t}}{n_{i,t}} = \frac{\Delta N_{i,t}}{N_{i,t}} = -\pi_i \frac{\Delta N_t^R}{N_t^R} \frac{N_t^R}{N_{i,t}} \quad (5.1)$$

The assignment rule to a particular city π_i can be estimated from the equation above. The average ratio of rural population to Beijing and Shanghai population are 52.75 and 45.65, respectively, from 1994 to 2011. Therefore, from equation (5.1) we can then compute the fraction of migrants to Beijing and Shanghai are 3.4 and 3.9 percent, respectively. In 1994, the percentage of Beijing, Shanghai, and the rest of the cities is 1.03, 1.17, and 26.8 percent respectively. The remaining 71.0 percent resides in the rural areas. Given the values of $\{n_{B,0}, n_{S,0}, \pi_B, \pi_S\}$, it is straightforward to calculate the sequences of $\{n_{B,t}\}$ and $\{n_{S,t}\}$ from $n_{i,t+1} = n_{i,t} + \pi_i(n_t^R - n_{t+1}^R), i \in \{B, S, O\}$.

To complete the calibration of the multi-city model it is necessary to determine the land supply and the entry fees in each city. The total land area is 164,100 square kilometers in Beijing and 82,400 in Shanghai. The ratio of residential land is defined to be the fraction of residential land area in total land area of each city. From 1998-2007, the average ratio of residential land is about 20 and 22 percent in Beijing and Shanghai, respectively. In each city, the entry fees are collected by the local government. Similar to the case of one-city, we assume initial population in each city migrated from rural area at once and the initial entry fee for the housing developers is set to be the same as the one-city case in each city, and thus equals to ϕH_{-1} .

For the projected variables, Figure 11 compares the evolution of population in Beijing

and Shanghai for the period 1996 and 2011 in the data and the model. The model is designed to target the imputed data based on the average value of π_i . Both panels below show the fraction of population in each city from which we can see that the implied population growth of the cities computed from the model are similar to the data.

The flow of migration combined with supply factors generates a sequence of housing and land prices for each city for the period 1999-2008. The implied prices generated by the model are compared with the data in Table 5. The model captures quite well the average growth and the movements of prices and output across the two cities. In particular, it accounts for 84.7 percent of housing price, 75.7 percent of land price, and 84.5 percent of output changes in Beijing. In the case of Shanghai, the model accounts for 84.7, 73.9, and 85.6 percent respectively.

The dynamic evolution of predicted housing and land prices together with the data are depicted in Figure 12. To understand the patterns in the data it is useful to decompose the sample into three sub-periods:

- **1999-2001:** During this period the economy was affected by the financial crises in Asia and the burst of the dot-com bubble. The result was a high level of unemployment rate, especially for those workers at SOE. The gradually deepening economic reform encouraged more and more productive private enterprises to enter the market. Beijing, as the capital of China, used to be the headquarter of many SOE, and thus more workers were laid off compared to Shanghai.
- **2002-2004:** The spreading of the SARS virus by the end of 2002 affected Beijing much more severely than Shanghai in 2003.
- **2005-2008:** This period is characterized by rapid growth leading to the olympic games in Beijing. The sample stops before the financial tsunami that impacted the economy in China in 2009.

The model captures the “flying geese pattern” of city development discussed by Kasahara S.(2004) and Ozawa, T. (2005). As an early starter, Beijing has passed over more and more industrial production to Shanghai, and hence the latter has attracted a larger scale of labor force to work there. This explains why housing price in Beijing were higher than Shanghai in the sub-period 1999-2001. Across the two cities and the three sub-periods, the model performs quite well with the exception of the second sub-period in Beijing. As mentioned before, the spreading of the SARS virus significantly reduced the migrations flows to the city of Beijing. Since in the model housing prices are critically driven by migration flows, a much larger decline in housing prices relative to the data is predicted. This underprediction is also responsible for the relatively low average growth in housing prices.

Both Beijing and Shanghai have traditionally been the industrialized cities in Chinese history. Ever since the reform and open policy has been implemented in China, they have been the main receivers of rural population. The fact that the model can explain a sizeable

fraction of the housing prices growth in both cities furthermore consolidates the idea that structure change plays crucial role in housing prices growth in industrialized cities.

In the model, both cities have similar migration flows coming in. The main differences for the price dynamics have to result from institutional features working through the supply factors. To assess the importance of these factors, we decompose its relative contribution for the full sample and the different subperiods. The results of the decomposition are summarized in Table 6.

For both cities, productivity growth is the most important driver of housing prices accounting for 53.3 percent and 57.1 percent respectively in Beijing and Shanghai. These numbers are larger than the findings for the national economy with a single city. The analysis at the city level seems to indicate that agglomerations could be very important drivers of housing prices in these two cities. This is consistent with the empirical evidence. For land prices, both land supply and productivity are important. Together these factors capture more than 70 percent in each city, with a smaller contribution than the national decomposition. This is mainly due to a larger impact of finance on the price of land in the cities.

The contribution of productivity across cities is comparable in the second and third sub-periods. In the initial sub-period, the relatively high income growth in Shanghai than Beijing is the driver for the different growth in house prices across these two cities. The relatively low productivity in Beijing captures the low growth in employment and migration flows due to the lay-off of the SOE workers. Despite the relative contribution of productivity in the two cities is comparable in the second sub-period, it is important to note that there is a stagnation of housing prices in Beijing due to a productivity slow down. Again, the impact of the SARS virus is captured by low migration flows and hence low income growth (productivity).

Supply factors become more important over time for explaining housing price movements in the period of the largest increase. This can be seen in the decomposition of the last sub-period, where supplied factors contribute 42 percent and 48 percent to the growth of housing prices in Beijing and Shanghai. Consequently, the role of productivity declines over time from 54 percent to 45 percent in Beijing, and from 71 percent to 42 percent in Shanghai. This suggests that productivity alone is not sufficient to account for the rapid increase in housing prices from 2004 onward. The regulation of housing developments and land supply also play an important role.

In the case of land prices, supply restrictions become more important in Beijing accounting about 60 percent in the last two sub-periods. In the case of Shanghai, the contribution of these factor are smaller, capturing only about 45 percent. Productivity has reverse roles in the two cities. In Beijing, its contribution dropped from almost 50 percent to 23 percent, whereas in Shanghai its importance raises from 25 percent to 50 percent. This is due to the fact that land availability was larger in Shanghai than Beijing and the manufacturing sector in Shanghai outgrew Beijing in the later period.

6. Conclusions

This paper uses a dynamic general equilibrium framework to investigate the role of structural transformation played in the rapid growth of housing and land prices in China. The benchmark economy incorporates three major channels: (i) the increased productivity of the manufacturing sector that leads to higher income and ability to pay, (ii) the relatively inelastic supply of housing that is limited by incremental city land released by the government and the controlled entry of real estate developers, and (iii) the continual rural-urban migration that fosters an on-going increase in urban housing demand. The quantitative findings suggest that the process of structural transformation and urbanization are important drivers of housing and land price movements in China, accounting for 67.1 percent of housing and 68.4 percent of land price movements over the period from 1992 to 2007. The model performance improves substantially when looking at Beijing and Shanghai suggesting that market fundamentals captured by structural transformation remain sizeable driver of housing prices between 1998 and 2007.

So what are the important policy implications derived from this research? The immediate one is that China's housing prices do not seem to be at odds with market fundamentals, contrary to beliefs by the majority of economic commentators. This does not necessarily imply that certain markets could have some deviations from fundamentals. Nonetheless, if China's urban housing boom is a concern by conservatism measures, then our results suggest that for large cities, if you want to slow down growth of house prices, supply policies are more important than credit conditions. At national level the analysis implicitly includes smaller cities. In this cases where wage growth is low, financial policies are as important as supply regulations.

In our model economy, we have, for tractability, neglected some potentially important margins, which may be explored in the future. The first, and perhaps the most important, extension is to add an intensive margin of housing demand to allow existing residents to change houses within the city. In so doing, however, it requires to keep track of the distribution of assets and mortgage balances across individuals, which would complicate the analysis greatly. The second extension is to add urban externalities, including both positive spillovers and negative congestion factors. Finally, one may extend our model to allow for foreign investments in urban areas, often subsidized by governments, that encourages urban growth.

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Table 1: Predetermined Parameters

Parameter	Model	Value
β	Subjective discount rate	0.95
A_t^f	Productivity in agriculture sector	1.00
ϕ	downpayment ratio	0.30
r^*	annual interest rate	0.04

Table 2: Benchmark Parameter Values and Calibration

Model	Parameter	Value
Relative productivity of the manufacturing sector	$\{A_t^m\}$	
Share agriculture goods in utility function	θ	0.78
Elasticity of substitution utility function	ρ	0.81
Curvature Pareto distribution: $F(\epsilon) = 1 - (\frac{1}{\epsilon})^\lambda$	λ	2.8
Technology developers	α	0.2
Entry fee	ψ	4.5
Initial entry fee	H_{-1}	0.25

Table 3: Model Prediction 1992-2007 (%)

	Average Growth		Average
	Data	Model	Prediction
Housing Prices	8.61	8.62	67.1
Land Prices(*)	20.0	19.4	68.4
Aggregate Output	8.97	7.23	80.0

(*) Land prices are compared for the period 1999-2007

Table 4: Decomposition of Key Indicators

	Period	Entry Fee	Land supply	Downpayment	Productivity
Housing Prices	1992-2007	16.5%	11.7%	25.7%	46.1%
	1992-1996	20.0%	15.8%	24.6%	39.6%
	1997-2002	10.7%	7.0%	22.3%	60.0%
	2003-2007	19.6%	13.0%	31.0%	36.5%
Land Prices	1999-2007	15.3%	32.4%	6.0%	46.3%
	1999-2002	11.6%	38.8%	7.9%	41.8%
	2003-2007	18.6%	26.8%	4.4%	50.2%
Fraction of City Population	1992-2007	-13.5%	-10.8%	10.0%	114.3%
	1992-1996	-2.0%	-2.0%	0.1%	103.9%
	1997-2002	-16.0%	-12.0%	9.0%	119.0%
	2003-2007	-25.0%	-20.0%	11.0%	134.0%

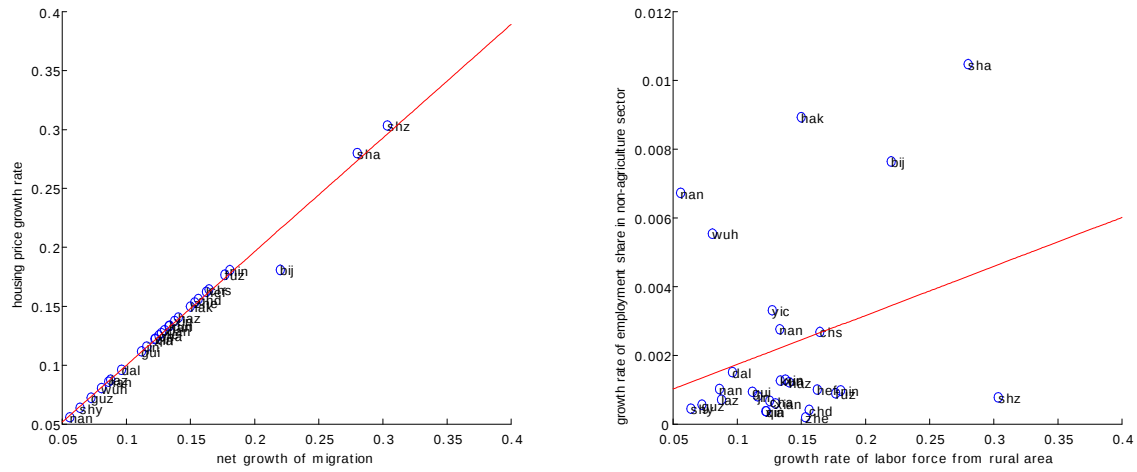
Table 5: Model Prediction 1999-2008 (%)

Beijing	Average Growth		Average
	Data	Model	Prediction
Housing Prices	2.95	1.03	84.7
Land Prices	37.9	34.9	75.7
Output	6.78	5.75	84.5
Shanghai			
Housing Prices	10.2	9.42	84.7
Land Prices	32.8	35.1	73.9
Output	6.89	5.89	85.6

Table 6: Decomposition of Key Indicators in Cities

	Period	Entry Fee	Land supply	Downpayment	Productivity
Beijing Housing Prices	1999-2008	19.8%	13.8%	13.1%	53.3%
	1999-2001	18.7%	13.1%	14.6%	53.6%
	2002-2004	14.3%	10.0%	11.3%	64.4%
	2005-2008	24.6%	17.2%	13.0%	45.1%
Beijing Land Prices	1998-2008	14.0%	37.9%	15.9%	32.2%
	1998-2001	9.9%	28.5%	12.7%	49.0%
	2002-2004	20.2%	45.0%	17.2%	17.7%
	2005-2008	14.7%	43.5%	18.5%	23.3%
Shanghai Housing Prices	1999-2008	19.2%	13.5%	10.3%	57.1%
	1999-2001	11.9%	8.3%	8.8%	71.0%
	2002-2004	14.5%	10.1%	11.8%	63.7%
	2005-2008	28.0%	19.6%	10.4%	42.0%
Shanghai Land Prices	1998-2008	11.7%	33.8%	14.9%	39.6%
	1998-2001	18.8%	35.0%	21.6%	24.5%
	2002-2004	14.8%	32.6%	16.1%	36.4%
	2005-2008	6.1%	34.2%	11.0%	48.7%

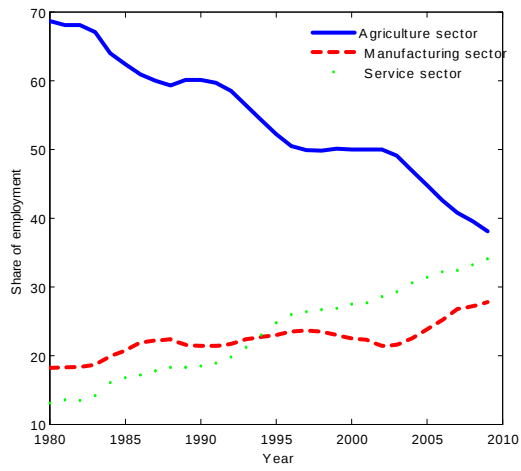
Figure 1: Strutural Change, Migration, and Housing in Chinese Cities



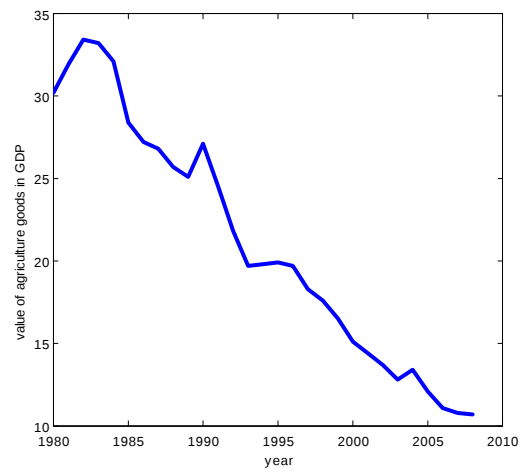
Source: National Bureau of Statistics of China

Figure 2: Structural Transformation in China

Sectoral Share of Employment

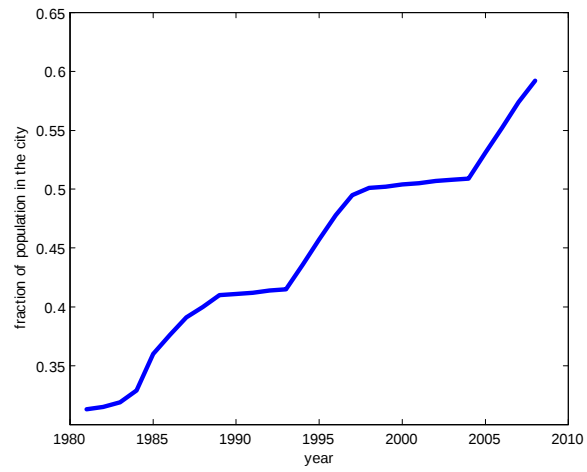


Agricultural Share in GDP



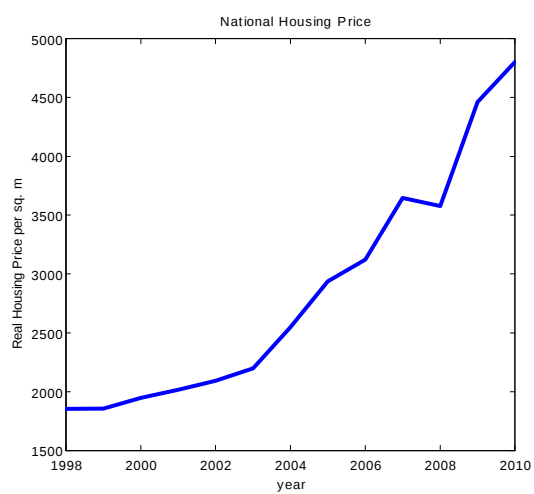
Source: National Bureau of Statistics of China

Figure 3: Fraction of Urban Population



Source: National Bureau of Statistics of China

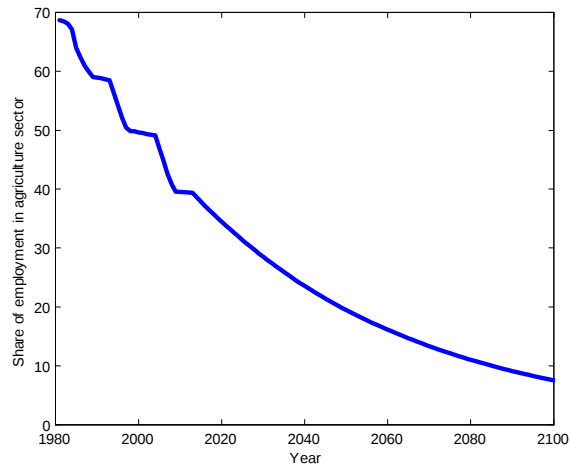
Figure 4: Housing Prices Evolution in China



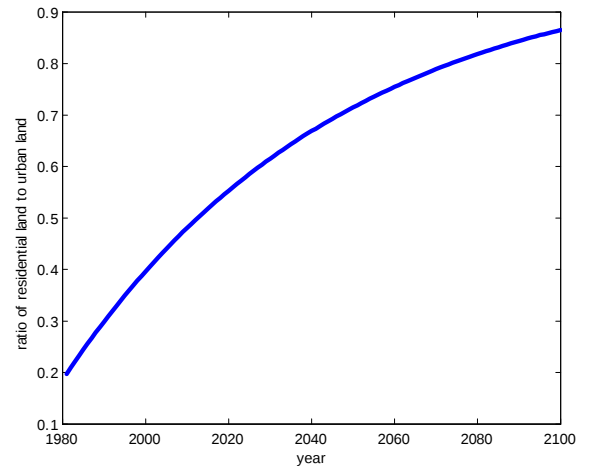
Source: National Bureau of Statistics of China

Figure 5: Projected Structural Change

Share Employment Agriculture Sector

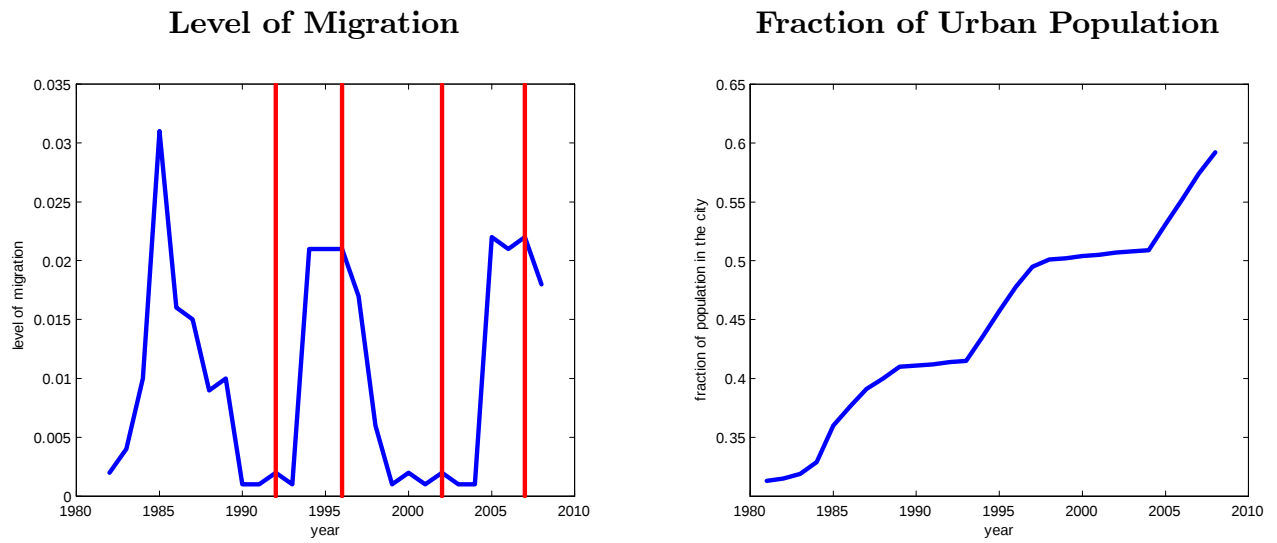


Ratio of Residential-Urban Land



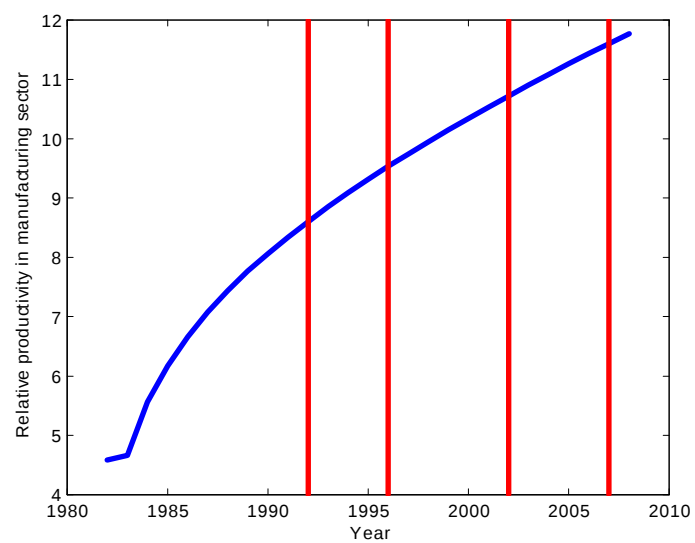
Source: National Bureau of Statistics of China and Model Implied Data

Figure 6: Population Dynamics



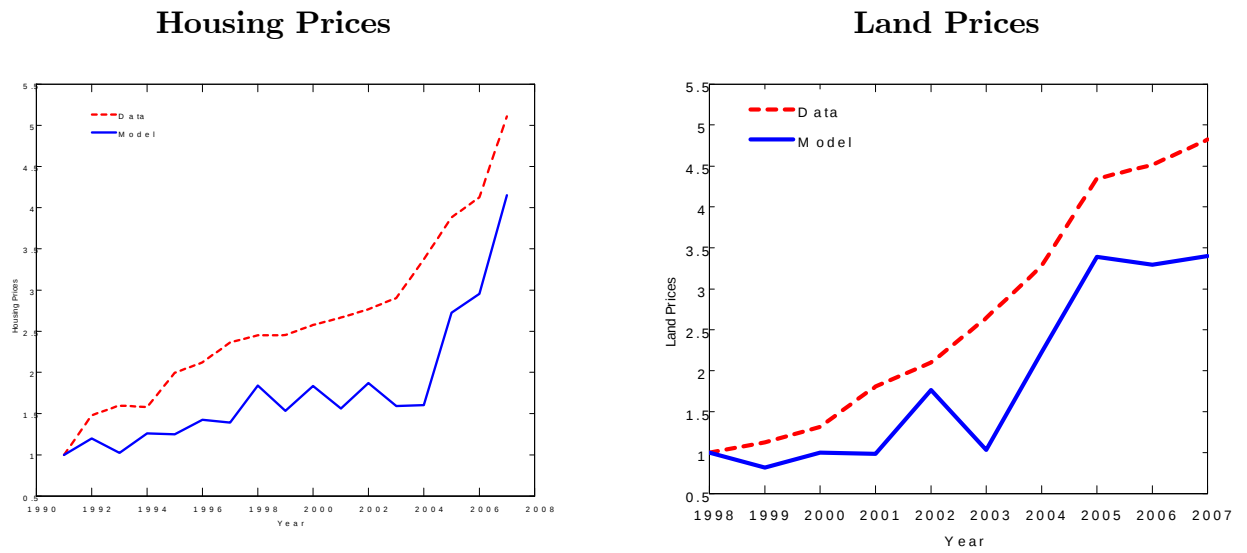
Source: Chinese Yearly Statistical Book

Figure 7: Relative Productivity of the Manufacturing Sector



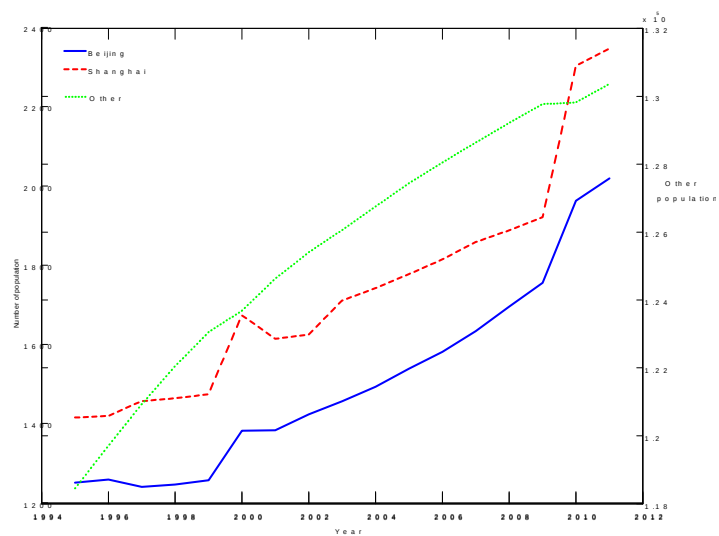
Source: Model implied data

Figure 8: Housing and Land Prices



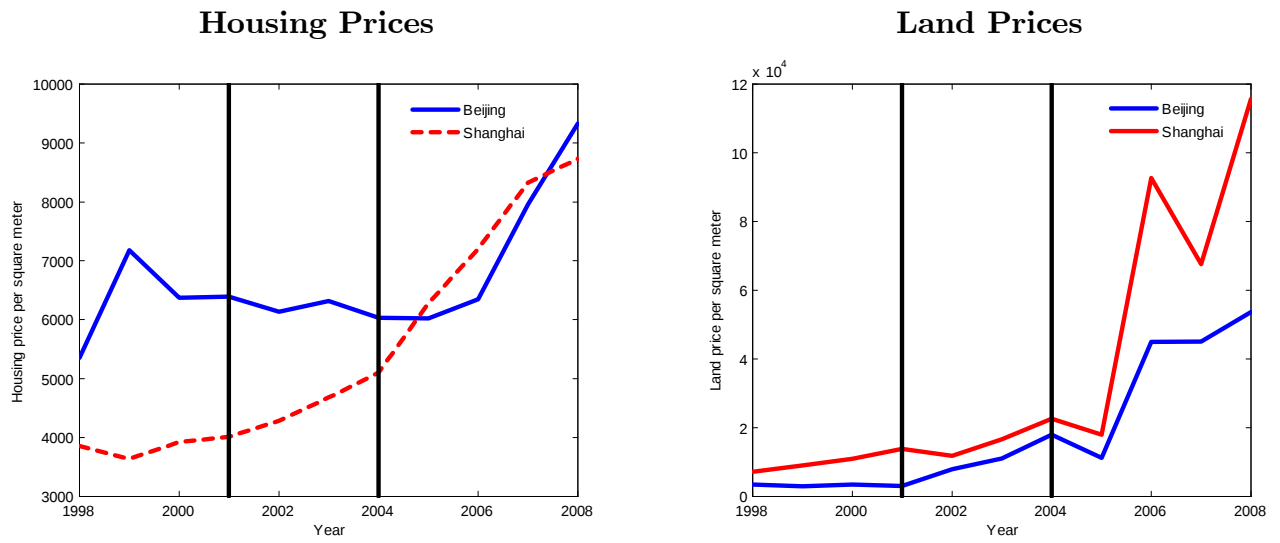
Source: National Bureau of Statistics of China and Model Implied Data

Figure 9: Total Population in Beijing and Shanghai



Source: National Bureau of Statistics of China

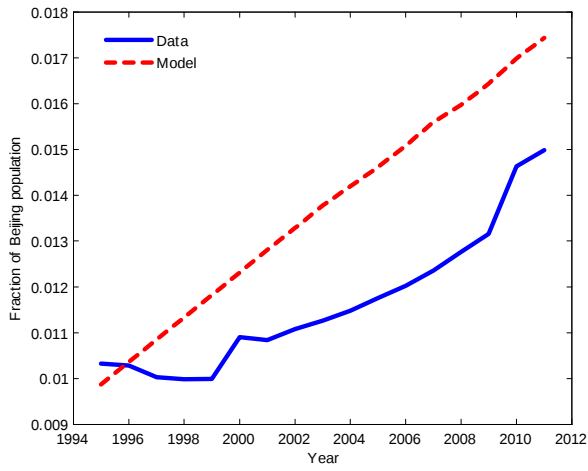
Figure 10: Real Housing and Land Prices in Beijing and Shanghai



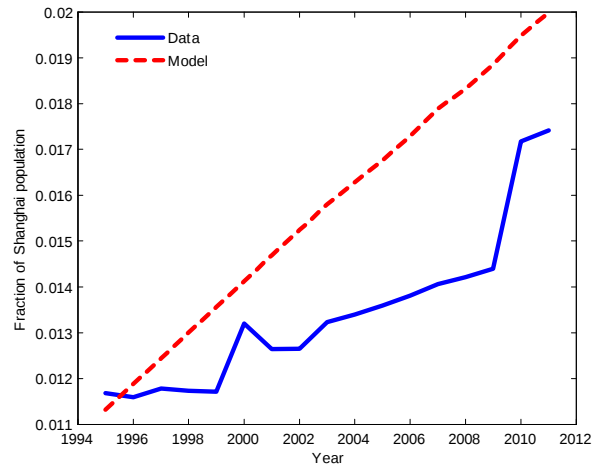
Source: National Bureau of Statistics of China

Figure 11: Population Dynamics in Cities

Fraction of Beijing in Total Population



Fraction of Shanghai in Total Population



Source: National Bureau of Statistics of China and Model Implied Data

Figure 12: House Prices in Beijing and Shanghai



8. Appendix

8.1. Propositions

Proposition 1: Consol FRM has zero amortization, $b_t = b_{t+1}$.

Proof: Mortgage payment contains two parts: amortization and interest payment. Amortization is defined to be the difference between today's debt and tomorrow's debt.

$$\begin{aligned} m_t &= a_t + i_t \\ a_t &= b_t - b_{t+1} \end{aligned}$$

Debt level in period 0 is $b_0 = (1 - \phi)q_0h$, interest payment in period 1 is $i_1 = (\frac{1}{\beta} - 1)(1 - \phi)q_0h$. Assume mortgage payment decreases at constant rate g over time. No arbitrage condition will give:

$$(1 - \phi)q_0h = \sum_{t=1}^{\infty} \beta^t d_1 (1 - g)^t$$

We can solve d_1 as follows:

$$d_1 = (1 - \phi)q_0h \frac{1 - \beta(1 - g)}{\beta(1 - g)}$$

Therefore amortization in period 1 can be derived as:

$$a_1 = d_1 - i_1 = g(1 - \phi)q_0h$$

Therefore under constant debt repayment scheme, amortization is zero.

Proposition 2: The downpayment constraint is always binding.

Proof: Consider parameter values $\{A_t^m\}$ such that there are no reversals from the city to the rural area. In this case, the relevant optimization problem becomes:

$$\begin{aligned} V_t^C(\epsilon, b_\tau) &= \max U(c_t^m, c_t^f, h_t) + \beta V_{t+1}^C(\epsilon, b_\tau) \\ s.t. \quad & p_t c_t^f + c_t^m + b_\tau r^* = w_t^m \end{aligned} \tag{8.1}$$

We rewrite the optimization problem sequentially and it becomes:

$$\begin{aligned} & \max \sum_{t=0}^{\infty} \beta^t U(c_{\tau+t}^m, c_{\tau+t}^f, h_\tau) \\ s.t. \quad & c_\tau^m + p_\tau c_\tau^f + q_\tau h_\tau = w_\tau^m + b_\tau \\ & c_{t+\tau}^m + p_{t+\tau} c_{t+\tau}^f + b_\tau r^* = w_{t+\tau}^m, \forall t > 1 \\ & b_\tau \leq (1 - \phi)q_\tau h_\tau \end{aligned}$$

The lagrange has the form:

$$\begin{aligned}\mathcal{L} = & U(c_\tau^m, c_\tau^f, h_\tau) + \lambda_0(w_\tau^m + b_\tau - c_\tau^m - p_\tau c_\tau^f - q_\tau h_\tau) + \\ & \sum_{t=1}^{\infty} \beta^t [U(c_{\tau+t}^m, c_{\tau+t}^f, h_\tau) + \lambda_t(w_{t+\tau}^m - c_{t+\tau}^m - p_{t+\tau} c_{t+\tau}^f - b_\tau r^*) + \gamma((1-\phi)q_\tau h_\tau - b_\tau)]\end{aligned}$$

First order conditions with respect to $\{c_{t+\tau}^m, c_{t+\tau}^f\}$ and b_τ give the following:

$$\begin{aligned}c_{t+\tau}^m : & U_1'(c_{\tau+t}^m, c_{\tau+t}^f, h_\tau) = \lambda_t \\ h_\tau : & U_3'(c_\tau^m, c_\tau^f, h_\tau) - \lambda_0 q_\tau + \sum_{t=1}^{\infty} \beta^t U_3'(c_{\tau+t}^m, c_{\tau+t}^f, h_\tau) + \gamma(1-\phi)q_\tau = 0 \\ b_\tau : & \lambda_0 - \sum_{t=1}^{\infty} \beta^t \lambda_t r^* - \gamma = 0\end{aligned}$$

To show borrowing constraint will be binding, it is equivalent to show $\gamma > 0$. Collecting terms will give:

$$\gamma = \lambda_0 - \sum_{t=1}^{\infty} \beta^t \lambda_t r^* = U_1'(c_\tau^m, c_\tau^f, h_\tau) [1 - r^* \sum_{t=1}^{\infty} \beta^t \frac{U_1'(c_{\tau+t}^m, c_{\tau+t}^f, h_\tau)}{U_1'(c_\tau^m, c_\tau^f, h_\tau)}]$$

Therefore γ is positive as long as utility function is strictly increasing, weakly concave in the consumption component and $\beta \leq \frac{1}{1+r^*}$.