Migrant Workers and Cities in China*

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Abstract

The recent urbanization in China creates a large number of migrant workers who leave their hometowns and separate from their families to earn more in the city. This paper constructs a model to show how migrant workers shape cities in China. City with a larger initial proportion of skilled workers grows faster and attracts more skilled workers over the past decade in China. But the housing price in skilled city does not have a greater increase rather than that in low skilled city concurrently. The model claims that the skilled city turns to be more productive but the total consumption there does not increase a lot, since the production and consumption of migrant workers are separated. Thus, the real wage in the skilled city declines slowly with the expansion of city. Agglomeration is enhanced.

Keywords: Urbanization, Family Separation, Skilled City, Migrant Workers, Agglomeration, China

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1 Introduction

China had been experiencing fast urbanization in the past decades. By 2010, the Mainland China had a total urban population of 6.66 million or 49.68% of the total population (China Census, 2010), rising from 26.4% in 1990. Most of urban population concentrate in several superstar cities in China. For example, 19.61 million and 23.01 million population live in Beijing and Shanghai based on the 2010 census data. They are listed as the largest cities in various sources of cities size ranking[1]. Besides the agglomeration of population, superstar city also have a higher skill share. For example, 19.3% population in Beijing and 12.3% population in Shanghai have a university degree or above in 2010, comparing with the median value of about 2.2% among all prefectural cities[2].

Housing price rises dramatically with the rapid urbanization in China. Real prices increased by about 225% over the past decade; and high price-to-rent ratios across the whole country imply high risk in housing market (Wu, Gyourko and Deng, 2012). But the growth of housing price does not show significant heterogeneity among cities as US that documented by Glaeser (2000), Liao (2010), Gyourko, Mayer and Sinai (2013). The estimation on China market reports close growth rates of housing prices among cities, about 4% annually from 2006 to 2010 (Wu, Deng and Liu, 2014).

The unique institutional setting, "Hukou" system, cannot be neglected when talking the formation of Chinese cities. A "Hukou" is a record in the system of household registration required by law in Mainland China. The system is promulgated to control the movement of people. People who worked outside their authorized domain or geographical area would not qualify for grain rations, employer-provided housing, or health care. It is relaxed since 1990s. China government gradually allows people working in cities that are not their registered place[3].

[1]How one defines the land area of a city, however, is key to determining its population. In different cities' size ranking, different definitions are used to indemnify the boundary of city, such as urban area, metropolitan area, and city proper.

[2]According to the administrative divisions of Mainland China, China urban system is organized by three level of cities, namely municipalities, prefectural cities, and county-level cities. As of 2014, there are total 4 municipalities, 286 prefectural cities and 364 county-level cities.

[3]In 1990s, a provision is made to allow city government to sell "temporary urban residency permits", so non-Hukou workers could work legally within the cities. The fee for these permits decreased over time and have become reasonably affordable. Further relaxation of the system has happened in 2000s. The laws of custody and repatriation were repealed in 2003.

But there is also fear that its liberalization would lead to massive movement of people into the cities, causing strain to city government services, damage to the rural economies, and increase in social unrest and crime. The present "Hukou" system remains active and continues to shape Chinese economy.

Due to the attraction of job opportunities in cities and the restriction of "Hukou" system, millions of workers separate from their families and work as migrant workers, and most of them are from rural area[4]. According to National Bureau of Statistics, by the end of 2011, a total of 252.78 million migrant workers existed in China. The large number of family separations generates critical social issues. For example, the children of migrant workers are not allowed to enroll in the city schools, and they must live with their grandparents or other relatives in order to attend school in their hometowns. They are commonly referred to as the left-behind children. There are around 61 million such left-behind children, separated from their parents, as reported by 2010 census. It is almost the whole population of UK[5].

Generally, migrant workers in China are unskilled and few of them has received university or above education, because the "Hukou" system has weak restriction on the movement of skilled workers. Most of Chinese cities open their doors to educated workers[6]. The other feature of migrant workers is that they consume less in their workplace. According to the survey conducted by National Bureau of Statistics, the average monthly expenditure of migrant workers is only 892 RMB (about 145USD) in 2013, and more than 50% is for accommodation[7]. Most of their wages are used to support their families and boost the consumption in their hometowns.

This paper proposes a two-city model to explain the critical role of migrant workers and how it accounts for the economic facts of cities in China. The model comprises two production sectors. One sector provides tradable goods. It requires both skilled and unskilled workers, and productivity increases with the number of skilled workers due to knowledge spillovers. The other sector is local service industry and it employs unskilled workers only. Thus, the price of local service is decided by the wage of unskilled workers. The housing price is related to total demand

[4]They are usually known as farm workers or peasant workers, "*nong min gong*" in Chinese.

[5]See some reports in press: Andrew Browne, Left-Behind Children of China's Migrant Workers Bear Grown-Up Burdens, WSJ, 17/01/2014; April Ma, China Raises a Generation of "Left-Behind" Children, CNN, 04/02/2014.

[6]For example, Shanghai and Shenzhen implement a scoring system and award "Hukou" to educated family.

[7]See the report of the survey: http://www.stats.gov.cn/tjsj/zxfb/201405/t20140512_551585.html

and elasticity of housing supply.

The model includes both "pull" and "push" forces of agglomeration. In "pull" side, the knowledge spillovers increase the marginal output of labor due to higher productivity. Higher wage attracts more workers. In "push" side, the price of local service increases faster with higher skill share since the wage of unskilled work increases. And meanwhile housing price is boosted by the increasing income. Overall, the increasing price index reduces the real wage and blocks further agglomeration.

Family separation of migrant workers significantly impacts both "pull" and "push" forces in this model. Migrant workers enhance the supply of unskilled workers in skilled city. The marginal output of skilled workers diminishes slowly due to increasing number of unskilled workers. The local service is also supported by abundant unskilled workers. More importantly, the families of migrant workers do not live in the skilled city. They do not contribute extra demands on service and housing.

The model is simulated based on four scenarios that account for different economic institutions. First, workers and their families are not separated. It is as same as the literatures discussed before. Second, unskilled workers are distributed into two cities evenly and are not allowed to move. This scenario is similar to Chinese economy before economic reform in 1978. Third, the simulation checks the output of model with family separation of unskilled workers. The movements of unskilled families are still restricted. It is close to current economic transition in China. Fourth, I discover the results of the model if workers and their families can move freely and family separation of unskilled worker is also an option. The simulation results suggest that the agglomeration in the economy is highly depended upon the strength of knowledge spillovers and the elasticity of housing supply, because these parameters are related to the "pull" and "push" forces. However, if family separation is possible, agglomeration is always possible, especially when one city has a relative higher initial skill share.

The reason why initial skill share is important for agglomeration in the model is the existence of separation cost. Unskilled workers leave their families and work in other cities only when their earnings can cover the separation cost and their families' expenditure. The new migrant unskilled worker receives a relative higher wage when the difference of initial shill shares between two cities

is larger.

This paper extends the New Economic Geography (NEG) studies on factor mobility. My model setting follows the classic "core-periphery" (Krugman, 1991) set-up with two regions, two sectors and two specific workers. Unskilled workers are assumed to be much less mobile than skilled workers. But NEG models usually discuss the location of imperfectly competitive industries in the presence of increasing returns to scale based on different transportation cost[8]. In their model, one sector employs unskilled workers to produce a homogeneous good, which is perfectly competitive and freely traded; The other sector employs skilled workers to supply a differentiated good, which is monopolistically competitive, and costly traded (see, for example, Fujita and Thisse, 1996; Ottaviano, Tabuchi, and Thisse, 2001; Ottaviano and Thisse, 2002).

The agglomeration of skilled workers in China is explained as the impacts of migrant workers in this paper. It provides a new view on agglomeration theory. Most of the previous studies focus on productive advantages of skill concentration, such as knowledge spillovers (Moretti, 2004), learning externality (Davis and Dingel, 2012), and sharing of intermediate inputs (Davis and Henderson, 2008; Hendricks, 2011). From the perspective of consumption, the heterogeneous preference among different individuals is modeled to generate skill sorting (Gottlieb and Glaeser, 2006; Lee 2010; Gyourko, Mayer and Sinai, 2013; Zhang and Fu, 2014). My paper discusses that family separation of migrant worker prompts skill agglomeration since it impacts both production and consumption sectors.

The paper also adds to the literature on Chinese cities where the rapid urban growth in China is addressed. Researchers usually highlight the causes as the increment of real income in city (Au and Henderson, 2006), industry agglomeration (Lu and Tao, 2009; Zhao and Sing, 2014), urban amenity (Zheng, Kahn and Liu, 2010), infrastructure investment (Baum-Snow et. al., 2014) and political incentives on local officials (Lichtenberg and Ding, 2009; Li, 2011).

This study shares some commons with the literature addressing outsourcing and computerization (Autor and Dorm, 2013; Feenstra and Hanson, 1999; Liao, 2010; 2012). They claim that outsourcing and information technology assist the unskilled support services separate from skilled cities and reshape economic geography. The separation of skilled and unskilled tasks in

[8]See a review by Ottaviano and Puga (1998).

production drives the output of their models, while this paper emphasizes the separation of the production and consumption.

The remaining paper is organized as follows. Section 2 illustrates some empirical facts of cities in China. Section 3 introduces a two-city model. Section 4 discusses the impacts of family separation in the model. Section 5 presents the model's numerical results. Section 6 concludes.

2 Empirical Facts

This section presents four stylized facts of Chinese cities during 2000 to 2010. The changes in skill share, population growth, housing price growth and separated families among Chinese prefectural cities and municipalities are examined, using the share of skilled workers in 2000 as initial condition. The data source is introduced in the appendix.

2.1 Skill Share Increases Faster in Skilled Cities

Figure 1 plots the percentage of skilled workers[9] in 2000 against the change in percentage of skilled workers during 2000 to 2010. The correlation is above 90%. Skilled cities more successfully attract skilled workers after 2000.

[Figure 1 about here.]

A regression across Chinese cities is also implied to identify the relationship between the change of skill share and initial skill level of a city. The change of skill share from 2000 to 2010 is used as dependent variable. I regress it on the skill share of one city in 2000, and control economic variables, i.e. the city size and percentage of workers in 2nd sector in 2000, geographic variables, i.e. the area, the distance to closest port, temperature, province capital dummy, and municipalities dummy, and the province fixed effects. The results are shown in Column 1 of Table 1. The coefficient on the skill share in 2000 is significantly positive. 1 percentage increase of skill share in 2000 will add 1.198 increments to skill share in 2010. The coefficients on other

[9]Skilled workers are defined as people with a university degree or above. It is as same as the definition by Glaeser(1994), Berry and Glaeser (2005).

variables report that cities with less population, more 2nd sector industry and larger area will have a faster increase in skill share.

[Table 1 about here.]

The empirical finding here is similar with the experience of US. But the correlation is much higher than that of US, which is reported as 55% during 1980-2000 by Liao (2010), 44% in 1980s and 60% in 1990s by Berry and Glaeser (2005).

2.2 Population Increase Faster in Skilled Cities

Figure 2 depicts the population growth during 2000 to 2010 among cities with different skill share in 2000. The correlation is 56%. Cites with high initial skill share will grow faster in the following period. The similar regression as shown above is also implemented. The results in Column 2 of Table 1 report a significantly positive coefficient on the skill share in 2000. 1 percentage of skill share in 2000 contributes to about 8.13 percentage population growth in the following decade.

[Figure 2 about here.]

It is not surprised that skilled cities attract more population since the productivity is high there. To relocate into skilled cities will receive more wage. This phenomenon is also presented in western literatures such as Bacolod, Blum and Strange(2009), Combes, Duranton and Gobillon(2008).

2.3 Housing Price Growth is not related to Skill Share

Figure 3 examines the relation between housing price growth[10] and initial skill share among cities. The correlation is quite low, less than 5%. And the regression results in Column 3 of Table 1 also declare that the coefficient on the skill share is insignificant. Housing price growth is not related to the initial share in Chinese cities.

[Figure 3 about here.]

[10]Due to the limitation of data, the housing price growth from 2002 to 2010 is used here.

This result here is consistent with the calculation by Wu, Deng and Liu (2014) and different from the urban economic literature that generally focuses on US data. Glaeser and Saiz (2004) report that one percentage point increase in the initial skill share can increase housing price by 0.9 and 2.3 with a decade. Liao (2010) claims a 1.7 percentage housing price growth in response to 1 percentage increase in skill share from 1980 to 2000.

2.4 Migrant Workers Move into Skilled Cities

There are abundant migrant workers in China's urban system. It is a unique economic phenomenon. This paper uses the ratio of total population over registered population (with "Hukou") in one city as the indicator of migrant workers. If this indicator is bigger than 1, it implies that migrant workers move into this city; otherwise, some workers move out of this city. Meanwhile, the migrant workers indicator would capture the number of family separations. In China "non-Hukou" population faces serious discrimination as mentioned above. Most of migrant workers keep their families stay at the hometown.

[Figure 4 about here.]

Figure 4 plots the skill share in 2000 against the migrant workers indicator in 2010 among Chinese cities. The figure shows a positive correlation between initial skill share and migrant workers. The regression in Column 4 of Table 1 confirms this result. Migrant workers are more likely to move into city with higher initial skill share. And workers in the low skilled cities tend to separate from their families and work in the skilled cities.

3 Model

This section presents a two-city model, where two types of production and two types of workers are located in the two cities. It is an open economy without transportation cost. The families of workers consume tradable goods, local service and housing. Then, there is unskilled migrant workers and their family are separated in two cities costly. The analysis of this model will provide insight how Chinese family separation shapes Chinese cities.

3.1 Demography

There is H family in our model and each one provides one labor to production. $H = L$, where L is the total number of labor. The labor is not identical. L_h are skilled workers and L_u are unskilled workers. Workers can settle down their families in two cities. Each city is denoted by the subscript 1 and 2. The arrangement of labor in two cities is denoted as $L_{i,j}$ where $i \in \{u, h\}$ and $j \in \{1, 2\}$. H_h and H_u families provide skilled and unskilled labor, respectively. The number of families in each city is denoted as $H_{i,j}$. For skilled workers, $H_{h,j} = L_{h,j}$. Unskilled workers can choose to work in the same city as their families live or separate from their families. $|L_{u,j} - H_{u,j}|$ is the total number of separated unskilled families.

3.2 Technology

Assume two types of producers in each city. Production of tradable goods combines skilled managers and unskilled workers, using the following technology:

$$Y_{g,j} = A_j \left(L_{m,j}^{\mu} + \psi L_{w,j}^{\mu} \right)^{\frac{1}{\mu}},$$

where $L_{m,j}$ and $L_{w,j}$ denotes the number of skilled managers and unskilled workers employed by production of tradable goods in city j; ψ is the fraction of productivity between skilled managers and unskilled workers; μ denotes the elasticity of substitution; and $\psi, \mu \in (0, 1)$. And A denotes the level of knowledge spillovers, which is a function of the total number of skilled managers in the city:

$$A_j = L_{m,j}^{\gamma},$$

where γ indicates the strength of spillovers. This function illustrates that the knowledge spillovers only exist locally and skilled workers contributed to the spillovers[11].

Solve the problem of producer of tradable goods. The wage of skilled and unskilled workers,

[11]It is in line with the literature such as Fujita and Thisse (2003), Gleaser and Ponzetto (2010), Liao (2012). And the empirical work also support that the knowledge spillovers depend on highly educated workers, see, for example, Acemoglu and Angrist (2000), Charlot and Duranton (2004, 2006), Moretti (2004), Rauch (1993), Rosenthal and Strange (2004).

$w_{u,j}$and $w_{h,j}$, are decided at the marginal, respectively.

$$w_{h,j} = \gamma L_{m,j}^{\gamma-1}\left(L_{m,j}^{\mu} + \psi L_{w.j}^{\mu}\right)^{\frac{1}{\mu}} + \left(L_{m,j}^{\mu} + \psi L_{w,j}^{\mu}\right)^{\frac{1}{\mu}-1} L_{m,j}^{\gamma+\mu-1} \tag{1}$$

$$w_{u,j} = \psi L_{m,j}^{\gamma}\left(L_{m,j}^{\mu} + \psi L_{w,j}^{\mu}\right)^{\frac{1}{\mu}-1} L_{w,j}^{\mu-1} \tag{2}$$

Since labors can choose their sector frictionlessly, the wages of same type of workers are constant in one city.

The other type of producer provides local service employing unskilled workers with the following technology:

$$Y_{s,j} = \alpha L_{s,j},$$

where $L_{s,j}$ is the number of unskilled workers employed by local service industry in city j; $\alpha > 0$ is an efficiency parameter. The efficiency parameter is normalized as 1 in this paper. Solve the problem of producer of local service, the relative price of service, P_j, is equal to the wage of unskilled worker.

$$P_j = w_{u,j} \tag{3}$$

3.3 Preference

Family consumes tradable goods, service and housing. The utility function is

$$u_{i,j} = c_{i,j}^{(1-\beta-\rho)} s_{i,j}^{\beta} q_{i,j}^{\rho}, \forall i \in \{u,h\}, j \in \{1,2\}$$

where $c_{i,j}$, $s_{i,j}$, and $q_{i,j}$ are the consumption of tradable goods, local service and the quantity of housing by family with skill level i in city j; β and ρ are the share of service and housing. $\rho, \beta \in (0,1)$. The expenditure is supported by the wage of worker in the family. The budget constraint is

$$c_{i,j} + P_j s_{i,j} + R_j q_{i,j} = w_{i,j}, \forall i \in \{u,h\}, j \in \{1,2\}$$

where $P_j$is the price of local service in city j; R_j is the rent of housing in city j; and $w_{i,j}$is the wage of labor with skill level i in city j.

Solve the problem of family. It will allocated its wage as:

$$c_{i,j} = (1-\beta-\rho)w_{i,j}; \tag{4}$$

$$s_{i,j} = \beta w_{i,j}/P_j; \tag{5}$$

$$q_{i,j} = \rho w_{i,j}/R_j. \tag{6}$$

The optimized utility is

$$u^*_{i,j} = (1-\beta-\rho)^{(1-\beta-\rho)}\beta^\beta\rho^\rho\omega_{i,j}, \tag{7}$$

where $\omega_{i,j} = w_{i,j}/G_j$, defined as the real wage; and $G_j = P_j^\beta R_j^\rho$, defined as the price index in city j. Because $(1-\beta-\rho)^{(1-\beta-\rho)}\beta^\beta\rho^\rho$ is constant, the optimized utility is decided by real wage.

This model allow the separation of unskilled workers' family. The worker will stay in city m to earn the wage $w_{u,m}$ and their family stay in city n facing the price index $G_{u,n}$, where $n \neq m$. The allocation of consumption is:

$$c^s_{m,n} = (1-\beta-\rho)w_{u,m}; \tag{8}$$

$$s^s_{m,n} = \beta w_{u.m}/P_n; \tag{9}$$

$$q^s_{m,n} = \rho w_{u,m}/R_n. \tag{10}$$

The utility of separated family is discounted by a separation cost, δ[12]. The optimized utility function of separated family will be

$$u^{s*}_{m,n} = (1-\beta-\rho)^{(1-\beta-\rho)}\beta^\beta\rho^\rho\frac{w_{u,m}}{G_n}(1-\delta).$$

The real wage of migrant workers is

$$\omega^s_{u,m} = \frac{w_{u,m}}{G_n}(1-\delta)$$

[12]This model does not include transportation cost and assume that migrant workers spend few by themselves. The separation cost is a type of emotional and psychological loss. It is a discount of total utility.

3.4 Housing

Assume the two cities have the same housing supply function:

$$Q_j = R_j^{\xi} \tag{11}$$

where Q_j is the quantity of housing supplied in city j, andξ is the elasticity of housing supply. The supply function echoes the empirical findings such as Green, Malpezzi and Mayor (2005), Saiz (2010). This assumption also considers congestion costs. For example, in a standard internal structure for cities (Alonso, 1964; Behrens, Duranton and Robert-Nicoud 2010; Muth, 1969), each location is endowed with housing sites that serve as residences and that do not require labor input. Residents commute from home to working places in the central business district. The rent incorporates both land rents and commuting costs.

3.5 Equilibrium

The interior equilibrium is given a set of price $\{w_{h,1}, w_{h,2}, w_{u,1}, w_{u,2}, P_1, P_2, R_1, R_2\}$, allocation of labor $\{L_{m,1}, L_{w,1}, L_{s,1}, L_{m,2}, L_{w,2}, L_{s,2}\}$, allocation of family $\{H_{h,1}, H_{h,2}, H_{u,1}, H_{u2}\}$, and aggregate output $\{Y_{g,1}, Y_{g,2}, Y_{s,1}, Y_{s,2}, Q_1, Q_2\}$ such that:

1. The producers of tradable goods maximize profit. The wages of labors are equal to their marginal output. Equation 1 and 2 hold.

2. The producers of local service maximize profit. The prices of service are equal to the wages of unskilled workers. Equation 3 hold.

3. Family maximizes its utility. Equation 4-6 and 8-10 hold.

4. The housing supply function, equation 11, hold.

5. If family can relocated during two cities frictionlessly, real wages are non-different.

$$\omega_{h,1} = \omega_{h,2}$$

$$\omega_{u,1} = \omega_{u,2}$$

6. The real wage of separated family is equal to that of family staying together.

$$\omega^s_{u,m} = \omega_{u,n}$$

7. Labor markets clear.

$$L_{h,j} = L_{w,j}$$

$$L_{u,j} = L_{w,j} + L_{s,j}$$

8. Local service market clear.

$$Y_{s,1} = s_{h,1}H_{h,1} + s_{u,1}f(H_{u,1}, L_{u,1}) + s^s_{2,1}g(H_{u,1}, L_{u,1})$$

$$Y_{s,2} = s_{h,2}H_{h,2} + s_{u,2}f(H_{u,2}, L_{u,2}) + s^s_{1,2}g(H_{u,2}, L_{u,2})$$

where

$$f(x,y) = \begin{cases} x & \forall x \le y \\ y & \forall x > y \end{cases};$$

$$g(x,y) = \begin{cases} 0 & \forall x \le y \\ x - y & \forall x > y \end{cases}.$$

9. Housing market clear.

$$Q_1 = q_{h,1}H_{h,1} + q_{u,1}f(H_{u,1}, L_{u,1}) + q^s_{2,1}g(H_{u,1}, L_{u,1})$$

$$Q_2 = q_{h,2}H_{h,2} + q_{u,2}f(H_{u,2}, L_{u,2}) + q^s_{1,2}g(H_{u,2}, L_{u,2})$$

This paper focuses on the interior equilibrium, which exists and is unique within a plausible range of parameters. The following section shows the impacts on different settings on the final equilibrium of this model.

4 Family Separation Matters

This section summarizes the model presented above and shows the impacts of family separation on the economy. Workers and their families choose their locations without the consideration of equilibrium. They will choose to locate in the city with higher real wage. The real wage is decided by the nominal wage and the price index in one city. The arrangement of labor and family in the equilibrium make the real wage between two cities non-difference. The following analysis shows that the total income in one city is critical to the final equilibrium.

The total income of one city is defined as the sum of wage incomes for all families living here,

$$I_j = w_{h,j}H_{h,j} + w_{u,j}f(H_{u,j}, L_{u,j}) + w_{u,j}g(H_{u,j}, L_{u,j}),$$

where $I_j$is the total income of city j. If there is family separation, unskilled workers left their family in a secondary city and work in the primary city alone. If $H_{u,1} < L_{u,1}$, some migrant workers separated from their families and work in city 1. City 1 will be a primary city; and city 2 is a income city. The total income in the primary city 1 is

$$I_1 = w_{h,1}L_{h,1} + w_{u,1}H_{u,1}; \tag{12}$$

the total income in the secondary city 2 is

$$I_2 = w_{h,2}L_{h,2} + w_{u,2}L_{u,2} + w_{u,1}(H_{u,2} - L_{u,2}). \tag{13}$$

Proposition 1. *The rent of housing in city j is decided by the total income, I_j, and the elasticity of housing supply, ξ. $R_j = (\rho I_j)^{\frac{1}{1+\xi}}$.*

Proof. In the appendix. □

The total income represents the purchase power in one city. As the preference of each family is given, the total demand of housing in one city is a linear function of purchase power. The rent is calculated by the demand and the elasticity of housing supply following equation 11.

This proposition is an important stepping stone for the arrangement of labor and family

between two cities. It provides a force to discourage the growth of city. Once a city has high level return of labor, more workers will relocate to it. Thus, the total income of this city will increase. It leads to a higher rent of housing. Since the rent of housing is a component of price index, increasing total income of one city weaken the growth of real wage. If the real wage decreases, the city will stop growing.

Equation 12 and 13 imply that the income of one city is not directly decided by the production in one city, i.e. wage and workers. Migrant workers transfer their income from one city to other. The agglomeration of production is not surely push up the housing rent. City with less production still possibly has a greater increase of housing rent, because migrant workers can bring back their wages from other city.

Proposition 2. *Workers are more likely agglomerated when the elasticity of housing supply, ξ, is higher and the share of housing and service consumption, ρ and β, are lower.*

Proof. In the appendix. □

The intuition of this proposition runs as follows. Consider how workers choose their location. If workers tend to agglomerate in one city, the increase of wage should be faster than the increase of price index. The rent of housing and price of service increases with the wage. Lower shares of housing and service consumption reduce their contribution to price index. And the higher elasticity of housing supply lows the impacts of increasing demand on the rent. Overall, higher elasticity of housing supply and lower share of housing and service consumption make the price index in one city more slowly increase with wage. The real wage increases in an agglomerated city. The agglomeration of workers will continue.

Proposition 3. *Family separation makes the agglomeration of skilled workers possible.*

Proof. In the appendix. □

If there is family separations, some unskilled workers work in the primary city and their families live in the secondary city. The total income of families in the primary city increases slowly and that in the secondary city increases fast since migrant unskilled workers transfer income from primary city to secondary city as shown in equation 12 and 13. As I shown above,

it is meaningful for the price index in one city. First, less people live in primary city implies less demand of housing and lower housing rent. Second, more unskilled workers supply reduces the wage of unskilled workers in primary city, because the separated families of unskilled workers live in the secondary city with a lower price index, and unskilled workers will accept relative lower wage. Skilled workers will relocate to the primary city due to high wage and low price index.

The analysis in this section shows the key points of my model. Housing rent increases with the scale of city, and the agglomeration is blocked by the increasing rent. In an economy, where unskilled workers and families are allowed to separate, agglomerated city are not so crowd since some families do not live there; and local service is cheap due to increasing supply of unskilled workers. Agglomeration will be enhanced there.

5 Numerical Analysis

In this section, I numerically solve my model in four scenarios. (1) Workers and families are not allowed to separate, and they can relocate freely. (2) Unskilled workers and families are restricted to migrant. (3) Unskilled families are restricted to migrant, and unskilled workers can separate from their families. (4) Workers and families can choose their location freely, and the separation of unskilled families are allowed. The values of parameters are chosen carefully to account for Chinese economy. And this section also analyzes the sensitivity of some parameters, i.e. the elasticity of housing supply elasticity and the strength of knowledge spillovers.

5.1 Calibration

A set of parameters used in the benchmark model is determined based on the estimates in the previous studies or chosen based on statistical data in China. All parameters are listed in Table 2. Parameters are also perturbed one at a time, to see how sensitive the economy is to the parameter values in the following discussion.

The benchmark value of the elasticity of substitution, μ, between skilled and unskilled workers are set to 0.5. The value is within the range of the estimates given by a series literatures such as Freeman (1986), Katz and Murphy (1992), Ciccone and Peri (2005). The parameter, ψ, is set

to 0.5 since the productivity of high skill relative to low skill is about 0.47 in 1990 reported by Acemoglu (2002). He also observes a increasing trend in US. Thus 0.5 is used in this paper. The empirical studies show the increase of skill share will increase wage by 10% above in China (Liu, 2007). The strength of knowledge spillovers, γ, is chosen as 0.2.

The share of service and housing consumption is calculated based the data from China Statistics Yearbook. The share of service consumption is around 30% in 2000s. But the housing consumption reported there is quite low, about 10%. Chinese scholars widely argue that the official statistics underestimate the implied rent of owning housing. 30% is a more comfortable number.

Wang, Chan and Xu (2012) estimate the housing supply elasticity in China and claim that housing supply in China is moderately elasticity. I set ξ as 2 in the benchmark model. The cost of family separation in China is quite difficult to be estimated. As Chinese family are more likely to separate to earn more (Glenn, 1983), it implies a low separation cost. This model considers the discount rate of utility, δ, is 0.1 due to family separation. The ratio of skilled workers over total workers is set to 0.1 since census in 2010 shows the population with a university degree or above is about 10.27% of the total population in China. During the simulation, the total population is normalized as 1. $L_h = 0.1$; and $L_u = 0.9$.

[Table 2 about here.]

5.2 Scenario Analysis

Four scenarios will be simulated. They account for different economic institutions. (1) I consider a economy where labor can relocated freely and they cannot separated from their family. This setting is widely discussed by previous urban literature. (2) The unskilled families are evenly distributed between two cities and not allowed to relocate. Family separation is also not possible. It is as same as the situation of China before economic reform in 1978. "Hukou" system restrict the movement of families and workers. (3) Based on the setting of scenario 2, the simulation allows the separation of unskilled families. Some unskilled workers will work in other city as migrant workers. It is the phenomenon happened during China current economic transition. (4) Workers and families can choose their location freely. And family separation is also allowed.

For all above four scenarios, the skilled families will not separated and they can relocate freely. So the numerical solution is conducted as follows. First, given an arrangement $\{L_{h,1}, L_{h,2}\}$ of skilled workers between two cities, calculate the real wage of skilled workers $\{\omega_{h,1}, \omega_{h,2}\}$ in both cities when the unskilled workers reach the equilibrium conditions. Second, plot the difference of real wages of skilled workers, $\omega_{h,1} - \omega_{h,2}$, against the distributions between two cities. The horizontal axis is $L_{h,1}$[13] and the vertical axis is $\omega_{h,1} - \omega_{h,2}$. Third, for $L_{h,1} \in (0, L_h)$, if $\omega_{h,1} - \omega_{h,2} = 0$ and $\partial(\omega_{h,1} - \omega_{h,2})/\partial L_{h,1} < 0$, $L_{h,1}$will be a steady equilibrium point. Skilled workers will be distributed in two cities as $L_{h,1}$ and $L_h - L_{h,1}$. If $\omega_{h,1} - \omega_{h,2} < 0$ when $L_{h,1} \to 0$, skilled workers will tend to agglomerate in one city[14].

Figure 5 presents the simulation results of four scenarios in different parts. Part (a) shows the scenario with full mobility of labor. When unskilled workers have reached the equilibrium where their wages between two cities is non-different, the left figure plots the real wages difference of skilled workers against the population of skilled workers in city 1 and the right figure plots the population of unskilled workers against skilled workers in city 1. There is no steady equilibrium between 0 and L_h from the left figure. When $L_{h1} = L_h/2$, $\omega_{h,1} = \omega_{h,2}$. But this point is not steady. Starting from this point, if one unskilled worker relocate to city 1, the real wage of city 1 will higher than city 2 and more skilled workers will continue to relocate to city 1. Skilled workers will gather in one city and the unskilled workers also will agglomerate with skilled workers as shown in the right figure.

Part (b) describes the results of scenario 2. Since the migrations of unskilled workers are restricted, the model does not force the real wage of unskilled workers equal between two cities. The right figure shows that the system reaches a steady equilibrium when skilled workers are evenly distributed into two cities. And the left shows unskilled workers are restricted and evenly live in two cities. The result implies the restriction on unskilled workers will also affect the mobility of skilled workers since they are complement in production.

Part (c) reflects the results of scenario 3. Family separation is allowed. The real wage difference of skilled workers and number of family separation are shown in the left and right

[13]Because $L_{h,1} + L_{h,2} = L_h$, $L_{h,1}$can represent the distribution of skilled workers.

[14]This paper draw $\omega_{h,1} - \omega_{h,2}$ against $L_{h,1}$over $(0, L_h)$ since the model is not continuous at $L_{h,1} = 0$ or $L_{h,1} = L_h$.

figure of part (c) respectively. This scenario can be divided into two sections. In the range $(L_h/2 - l, L_h/2 + l)$, the economy is as same as scenario 2, because the wage difference of unskilled workers in two cities can not afford the separation cost. l is defined as: $w_{u,1} = \delta w_{u,2}$ when $L_{h,1} = L_h/2 - l$. Out of this range, some unskilled workers start to work as migrant workers. The number of family separation increases with the concentration of skilled workers as shown in the right figure. As discussed above, there is one steady equilibrium when skilled and unskilled workers are evenly distributed into two cities. And out of the range, skilled workers tend to agglomerate in one city. This results emphasize the importance of initial skilled share. If the initial skill share in one city is higher (more than $L_h/2 + l$), skilled workers will agglomerate to this city. And if the skilled workers evenly distributed in these two cities initially, they will not tend to agglomerate.

Part (d) shows the results of scenario 4. Similar with the results in scenario 3. It also can be divided into two sections. In the range $(L_h/2 - l, L_h/2 + l)$, the economy is as same as scenario 1. l is defined as $w_{u,1} = \delta w_{u,2}$ when $L_{h,1} = L_h/2 - l$. Out of the range, the family separation appears as shown in the right figure. The left figure of part (d) shows there is no steady equilibrium between 0 and L_h. Skilled workers will tend to stay in one city.

[Figure 5 about here.]

The arrangement of population and housing price in equilibrium are also calculated and reported in Table 3. Skilled and unskilled workers all agglomerate in one city in scenario 1; the housing price is very high. There is an empty city. In scenario 2, workers evenly stay in two cities and the housing prices between two cities are equal. There is two equilibrium points in scenario 3. Skilled workers are either evenly distributed or concentrated in one city. If skilled workers all stay in one city, the housing prices between two cities are still comparable. Housing price in skilled city is about 30% higher than unskilled city. Scenario 4 displays an equilibrium where skilled workers live in one city and a lot of migrant workers between two cities. The difference of housing price is less than that in scenario 3; and the number of family separation is more than scenario 3.

[Table 3 about here.]

5.3 Effects of Housing Supply Elasticity

Based on the benchmark model, I change the value of housing supply elasticity to observe its impacts on the equilibrium. Figure 6 compares simulation results when $\xi = 2$ and $\xi = 1.5$ respectively. The real wage difference of skilled workers over different skill distribution is shown in it. For scenario 1, when the housing supply elasticity decreases, skilled workers will not agglomerate. Lower housing supply elasticity implies that housing price increase faster with the demand. It has negative impacts on the agglomeration. Scenario 2 still has a steady equilibrium where workers are evenly distributed. Since unskilled workers are restricted, housing supply has little influence on the economy. The housing supply elasticity also has weak impacts in scenario 3. If there is no family separation, workers are still evenly distributed. If there is family separation, workers are not constrained. Scenario 4 has a structural change around the $L_{h,1} = L_h/2$ when there is no family separation. A new steady equilibrium is possible when $L_{h,1} = L_h/2$. But skilled workers still tend to concentrate. Overall, the results implies that the housing supply elasticity weakly influences the agglomeration pattern if there is family separation.

[Figure 6 about here.]

Panel B of table 3 shows the equilibrium when $\xi = 1.5$. Workers are evenly distributed between two cities in scenario 1 and 2. The housing price is lower than when $\xi = 2$. Since the low supply elasticity decrease the demand of housing. Scenario 3 and 4 both predict two equilibrium. When the skilled workers agglomerated in one city, some unskilled families will be separated. Housing prices between two cities turn to be more close.

5.4 Effects of Knowledge Spillovers

Knowledge spillovers are the driven force of agglomeration in this model. Figure 7 depicts the results when $\gamma = 0.2$ and $\gamma = 0.15$. When the strength of knowledge spillovers decreases, skilled workers are distributed into two cities in scenario 1. The benefit of agglomeration cannot support the increasing price in the city. The change of knowledge spillovers weakly influences the results in scenario 2 due to the highly restriction rule on unskilled workers. Lower strength of knowledge spillovers changes the breaking value in scenario 3. The city require a high initial skill

share to achieve the agglomeration of skilled workers. In scenario 4, low knowledge spillovers imply an equilibrium when there is no family separation. The strength of knowledge spillovers can determined the formation of agglomeration when labor mobility is free. But it does not have strong impacts on the agglomeration when there is family separation.

[Figure 7 about here.]

The distribution of workers and the housing price in equilibrium are shown in panel C of table 3. Scenario 1 and 2 have an asymmetric equilibrium. The housing price is higher than the results in the benchmark model. The wage of unskilled workers decreases due to lower productivity and the price of service also decrease. Family will consume more housing relative to service. And scenario 3 and 4 both have two equilibria. When the skilled workers agglomerate into one city, the results report a higher family separation in scenario 4 than that in the benchmark model. Due to the low knowledge spillovers, the skilled city will provide low wage to unskilled workers and more unskilled workers will turn to be migrant workers.

6 Conclusion

Millions of migrant workers leave their hometowns and work in skilled city to earn more in China. Their separated families living in low skilled city are supported by their wages. This arrangement originated from the "Hukou" system, a restriction of labor mobility. From the perspective of personal choice, family separation is a way to assist the family to earn a better life. Taking a look at the whole economy of China, migrant workers enhance the economic agglomeration and form Chinese urban system. The abundant supply of cheaper and less-consumed workers make skilled cities more productive and less expensive.

One important point must be addressed in the end of this paper. My model emphasizes the benefit of family separation on China agglomeration economy, but it definitely does not advocate or favor this arrangement enthusiastically. The huge social cost of family separation should not be neglected. To migrant workers, the wage premium they earn in the skilled city is equal to the scarification of the emotional ties to their family. And the extensive internal migration generates wide and critical social impacts on China society. For example, migrant workers usually have

a low standard labor contract, which allows employers to further violate labor rights such as low safety standard, limited access of social insurance and over time working without payment. It influences the improvement of labor standards in China. More importantly, as mentioned above, there are millions of left-behind children due to the family separation. They easily suffer health, emotional and psychological problems. The hurt on the next generation will bring long run impacts on China economy.

Appendix

A Data

My sample includes 245 prefectural cities and 4 municipalities based on the administrative divisions of China in 2000. The population data is from the Census in 2000 and 2010. They provides the total population, registered population and population with a university degree or above in one city. Note that the total population is defined as the population who live in the city when conducting the survey. It reflects the real scale of city and is only available in census data.

Housing price data is from CEIC database. It is a commercial database providing the data insights into both developed and developing economies around the world. It has the average housing price per square meter among 208 prefectural cities and 4 municipalities from 2002 to 2010 in China.

China City Statistical Yearbook 2001 provides information on the percentage of workers in 2nd sector and the total area of each city. They are used as the control variables in the regressions. The annual average temperature is from China Meteorological Database, that covers meteorological data from about 300 observation stations over china. We find the closest station for each city center, and use the average annual temperature over the 1990s reported by this station as the temperature of this city. The coordination of each city is generated from Google map and the distance to closest port is calculated based on the straight distance equation.

The description of each variable is listed in Table 4.

[Table 4 about here.]

B Proof

B.1 Proof of Proposition 1

Recall equation 6 and 10, the total housing demand in city j is

$$Q_j = \frac{\rho I_j}{R_j}.$$

Since the preference is given and family will spend a fixed propensity of income in housing, the total demand of housing is linearly related to total revenue. Substitute the equation above into housing supply function 11, the rent of housing is

$$R_j = (\rho I_j)^{\frac{1}{1+\xi}}$$

B.2 Proof of Proposition 2

The price index of each city can be written as

$$G_j = P_j^{\beta} R_j^{\rho} = w_{u,j}^{\beta} (\rho I_j)^{\frac{\rho}{1+\xi}} .$$

Consider the equilibrium condition 5, $\omega_{h,1} = \omega_{h,2}$ and $\omega_{u,1} = \omega_{u,2}$ if families and workers do not relocate between two cities. If workers tend to relocate into the primary city 1, $\omega_{h,1} > \omega_{h,2}$ and $\omega_{u,1} > \omega_{u,2}$. Substitute the above equation. The wage of workers between two cities should satisfy,

$$\frac{w_{h,1}}{w_{h,2}} > \left(\frac{I_1}{I_2}\right)^{\frac{\rho}{(1+\xi)(1-\beta)}} , \tag{14}$$

$$\frac{w_{u,1}}{w_{u,2}} > \left(\frac{I_1}{I_2}\right)^{\frac{\rho}{(1+\xi)(1-\beta)}} , \tag{15}$$

if worker agglomerate to one city. From above conditions, smaller $\frac{\rho}{(1+\xi)(1-\beta)}$ implies workers will agglomerate driving by smaller wage different. Workers are more likely agglomerated with higher elasticity of housing supply, ξ, lower share of housing and service consumption, ρ and β.

B.3 Proof of Proposition 3

We consider the workers initially distribute in two cities as $L_{h,1}$, $L_{h,2}$,$L_{u,1}$ and $L_{u,2}$. The wage is decided by equation 1 and 2. Recall the agglomeration conditions in proposition 2 as equation 14 and 15. If there is family separation, we have

$$\frac{I_1}{I_2}_{sp} = \frac{w_{h,1}L_{h,1} + w_{u,1}H_{u,1}}{w_{h,2}L_{h,2} + w_{u,2}L_{u,2} + w_{u,1}(H_{u,2} - L_{u,2})}.$$

If there is no family separation,

$$\frac{I_1}{I_2}_{nosp} = \frac{w_{h,1}L_{h,1} + w_{u,1}L_{u,1}}{w_{h,2}L_{h,2} + w_{u,2}L_{u,2}}.$$

Since $H_{u,1} < L_{u,1}$,

$$\frac{I_1}{I_2}_{sp} < \frac{I_1}{I_2}_{nosp}.$$

If there is family separation, equation 14 and 15 are more likely to be satisfied. Workers will agglomerate.

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Table 1: Empirical Facts

	Skill Share Growth	Population Growth	Housing Price Growth	Migrant Workers Indicator
	(1)	(2)	(3)	(4)
Percentage of Skilled Workers in 2000	1.198***	8.135***	13.767	16.908*
	(0.144)	(2.332)	(14.488)	(8.861)
Log (Population in 2000)	-0.003***	-0.003	0.247 (0.163)	0.218*
	(0.001)	(0.017)		(0.112)
Percentage of Workers in 2nd Sector, 2000	0.007*	0.018 (0.080)	0.130 (0.579)	0.187 (0.147)
	(0.004)			
Log (Area)	0.002*	-0.044***	-0.286**	-0.195**
	(0.001)	(0.016)	(0.116)	(0.087)
Log (Distance to Port)	-0.000	0.003 (0.004)	-0.013	0.008 (0.020)
	(0.000)		(0.075)	
Temperature	-0.000	0.002 (0.004)	0.003 (0.031)	-0.021**
	(0.000)			(0.010)
Province Capital	-0.001	-0.040	-0.741	-0.517*
	(0.005)	(0.092)	(0.496)	(0.304)
Municipalities	-0.001	-0.408**	-0.181	-1.173*
	(0.012)	(0.184)	(1.388)	(0.674)
Province Fixed Effects	Yes	Yes	Yes	Yes
Observations	249	249	212	249
R-squared	0.859	0.676	0.389	0.427

Note: *, ** and *** stand for significance level at 10%, 5% and 1%, respectively. Robust standard errors are in parentheses. For column 1, the dependent variable is the change in percentage of skilled workers 2000-2010; for column 2, the dependent variable is the growth of population during 2000-2010; for column 3, the dependent variable is the growth of housing price during 2002-2010; for column 4, the dependent variable is the ratio of total population over registered population in 2010. The estimation in column 1, 2 and 4 includes 245 prefectural cities and 4 municipalities; and column 3 includes 208 prefectural cities and 4 municipalities.

Table 2: Benchmark Values of Parameters

Parameter		Value	Source
Discount factor of unskilled workers	ψ	0.5	Freeman (1986), Katz and Murphy (1992), Ciccone and Peri (2005)
Elasticity of substitution between managers and operators	μ	0.5	Acemoglu (2002)
Strength of spillover	γ	0.2	Liu (2007)
Share of service consumption	β	0.3	China Statistics Yearbook
Share of housing consumption	ρ	0.3	China Statistics Yearbook
Elasticity of housing supply	ξ	2	Wang, Chan and Xu (2012)
Cost of Family Separation	δ	0.1	
Share of skilled workers	L_h/L	0.1	Census 2010

Table 3: Equilibrium Results

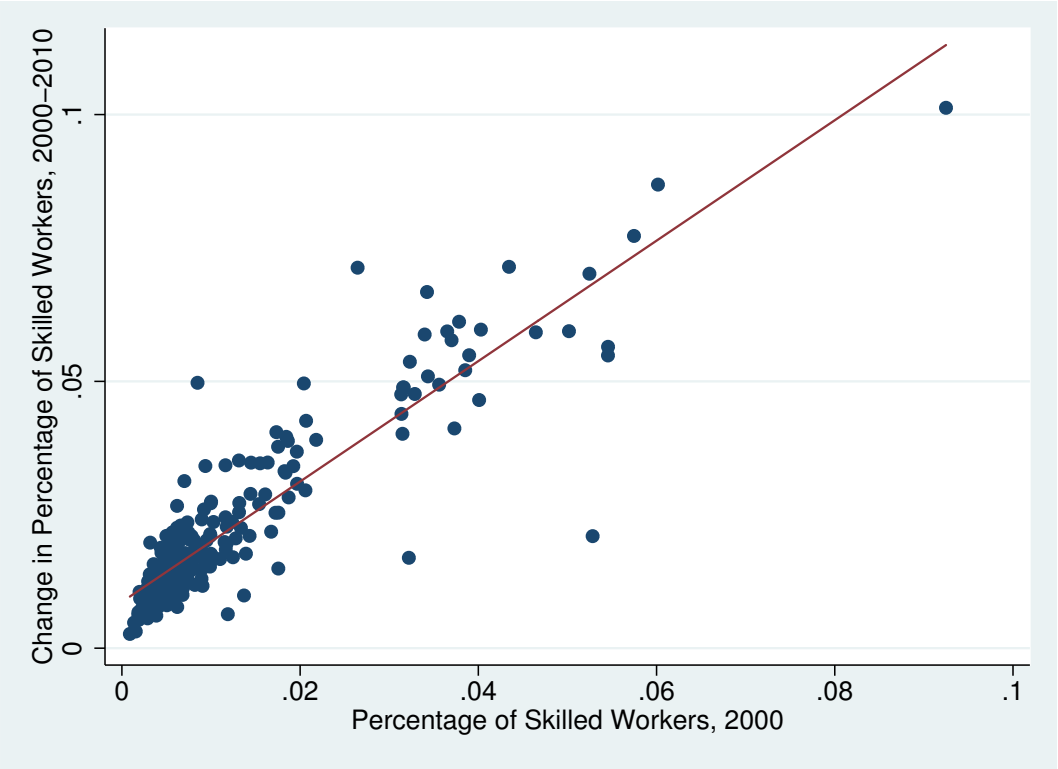
Scenario	$L_{h,1}$	$L_{h.2}$	$L_{u,1}$	$L_{u,2}$	$H_{u,1}$	$H_{u,2}$	R_1	R_2
Panel A: Benchmark Model								
1	0.100	0	0.900	0	0.900	0	0.516	-
2	0.050	0.050	0.450	0.450	0.450	0.450	0.392	0.392
3	0.100	0	0.755	0.145	0.450	0.450	0.458	0.343
	0.050	0.050	0.450	0.450	0.450	0.450	0.392	0.392
4	0.100	0	0.741	0.153	0.406	0.494	0.452	0.348
Panel B: $\xi = 1.5$								
1	0.050	0.050	0.450	0.450	0.450	0.450	0.325	0.325
2	0.050	0.050	0.450	0.450	0.450	0.450	0.325	0.325
3	0.100	0	0.755	0.145	0.450	0.450	0.392	0.277
	0.050	0.050	0.450	0.450	0.450	0.450	0.325	0.325
4	0.100	0	0.728	0.173	0.365	0.535	0.379	0.291
	0.050	0.050	0.450	0.450	0.450	0.450	0.325	0.325
Panel C: $\gamma = 0.15$								
1	0.050	0.050	0.450	0.450	0.450	0.450	0.407	0.407
2	0.050	0.050	0.450	0.450	0.450	0.450	0.407	0.407
3	0.100	0	0.755	0.145	0.450	0.450	0.470	0.355
	0.050	0.050	0.450	0.450	0.450	0.450	0.407	0.407
4	0.100	0	0.745	0.155	0.418	0.482	0.465	0.359
	0.050	0.050	0.450	0.450	0.450	0.450	0.407	0.407

Note: The table shows the all steady equilibrium points during the simulation. Panel A shows the results from benchmark model and parameters are listed in Table 2. Panel B changes the value of housing supply elasticity,ξ, and other parameters are still as same as benchmark model. Panel C uses different strength of knowledge spillovers, γ, and keeps other parameters as same as benchmark model.

Table 4: Description of Variables

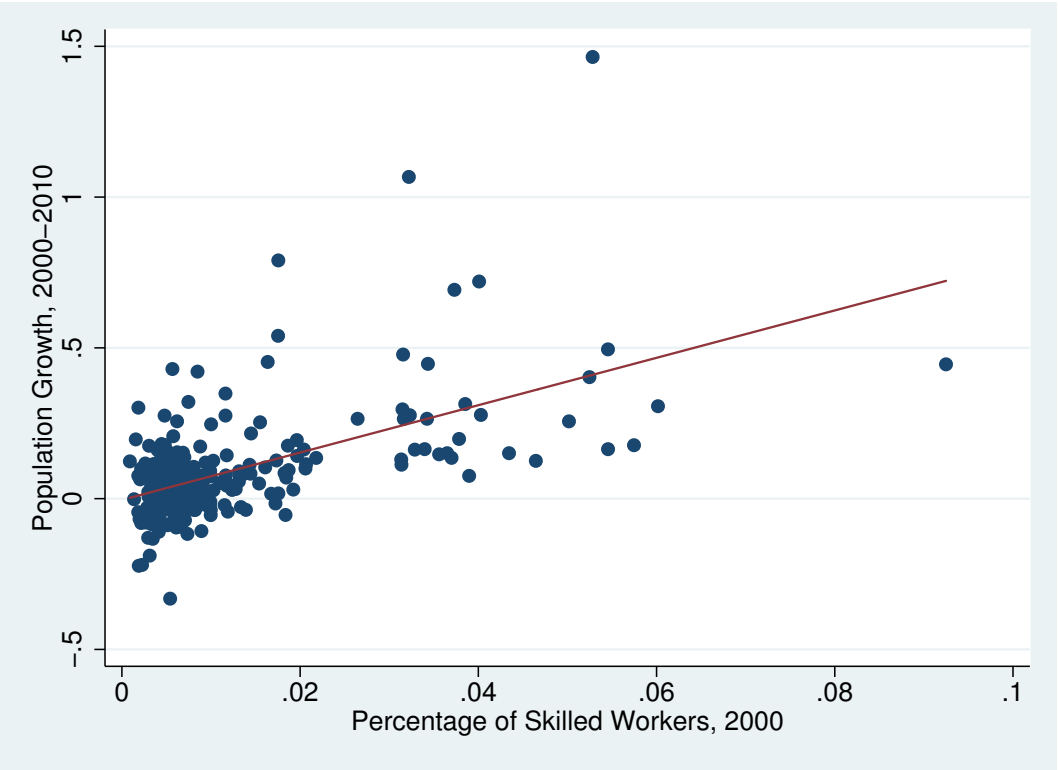
Variable	Description	Source
Population	The total population staying in one city.	Census, 2000, 2010
Migrant Workers Indicator	The ratio of total population over registered population.	Census, 2000, 2010
Population Growth, 2000-2010	The growth rate of total population from 2000 to 2010.	Census, 2000, 2010
Housing Price Growth, 2002-2010	The growth rate of average housing price per square meter from 2002 to 2010.	CEIC, 2002, 2010
Percentage of Skilled Workers	The ratio of population with university degree or above over total population.	Census, 2000, 2010
Percentage of Workers in 2nd Sector	The ratio of employees in manufacturing and service industries over total employees.	China City Statistical Yearbook,2001
Area	The size of total administration area.	China City Statistical Yearbook,2001
Distance to Port	The straight line distance between the city and the closest coastal port. The coastal ports are limited in the 14 coastal ports selected as open coastal cities by China government in the beginning of 1980s. They are Tianjin, Shanghai, Dalian, Qinhuangdao, Yantai, Qingdao, Lianyungang, Nantong, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang and Beihai.	Google Map
Temperature	The annual average temperature.	China Meteorological Database
Province Capital	A dummy variable. It is 1 if the city is province capital; otherwise 0.	
Municipalities	A dummy variable. It is 1 if the city is municipalities; otherwise 0.	

Figure 1: Skill Share Increases Faster in Skilled Cities



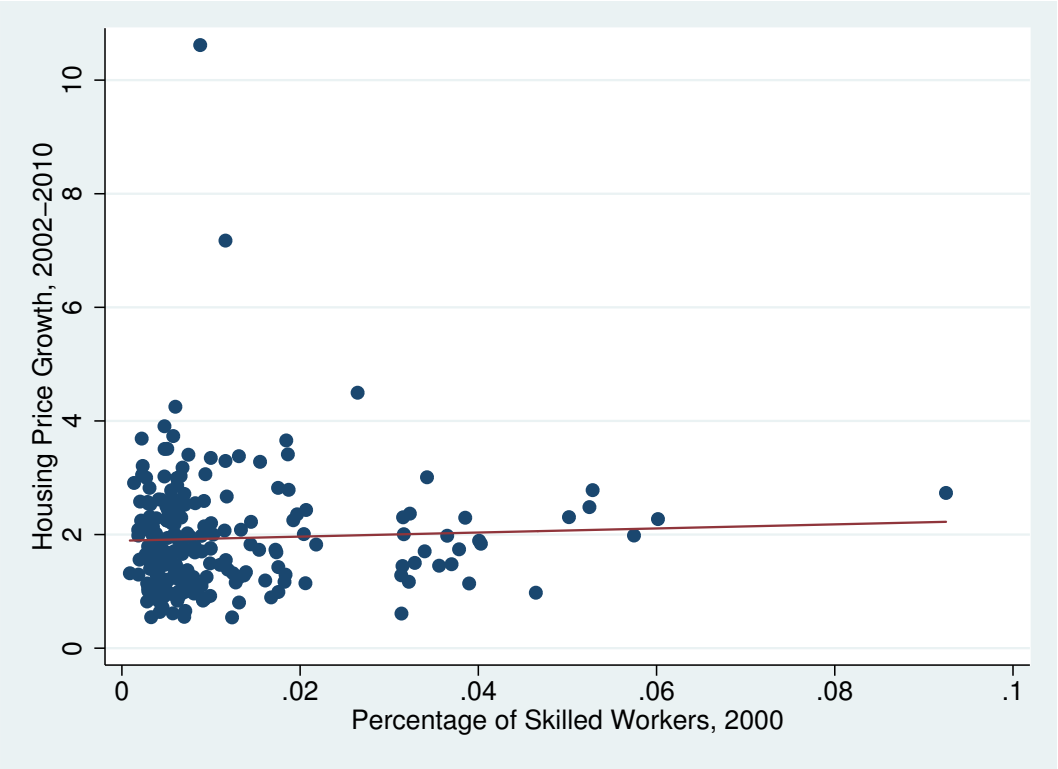
Note: The horizontal axis indicates the percentage of skilled workers in 2000; and the vertical axis is the change in percentage of skilled workers from 2000 to 2010. The straight line is the linear fixed value.

Figure 2: Population Increase Faster in Skilled Cities



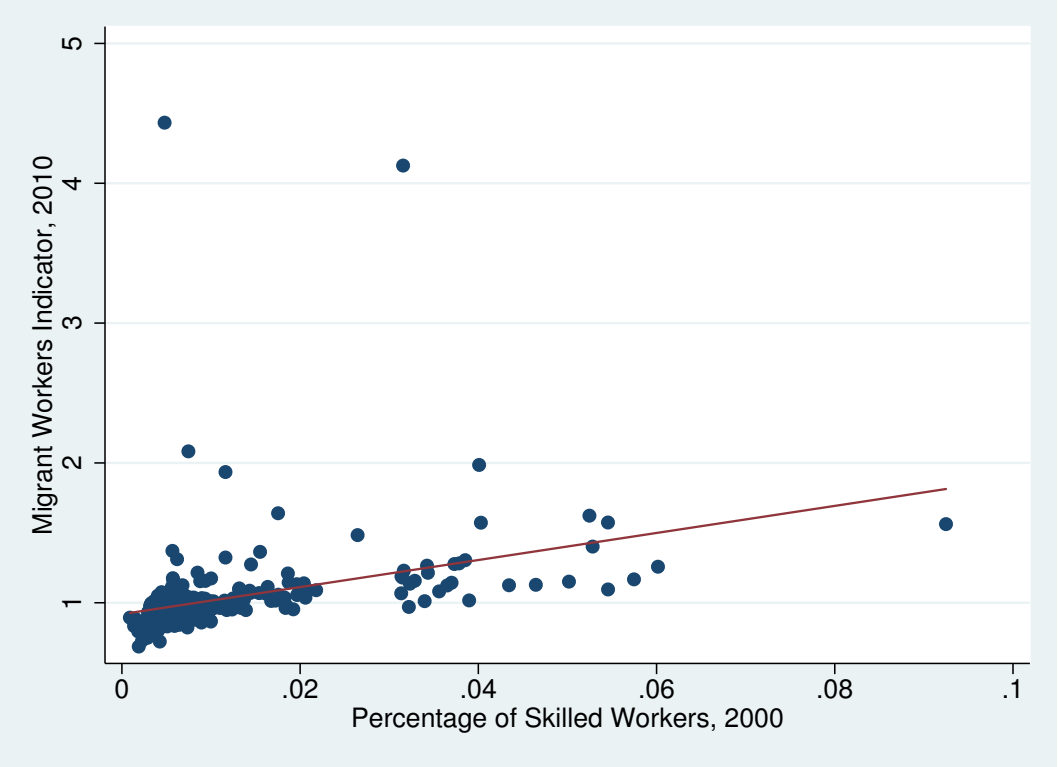
Note: The horizontal axis indicates the percentage of skilled workers in 2000; and the vertical axis is the population growth rate from 2000 to 2010. The straight line is the linear fixed value.

Figure 3: Housing Price Growth is not related to Skill Share



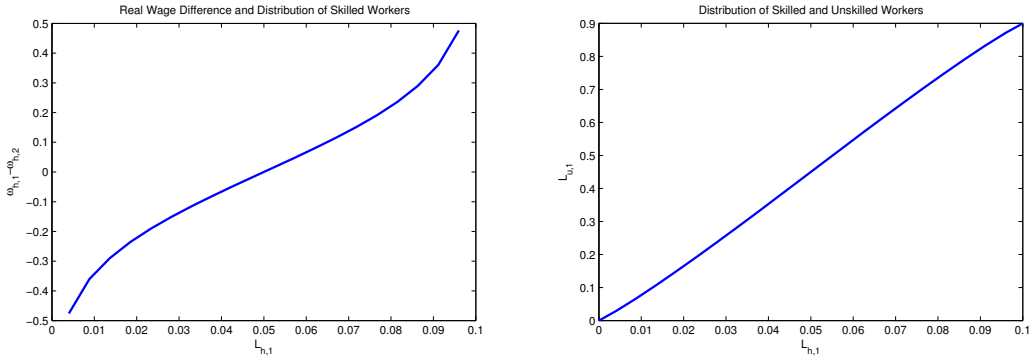
Note: The horizontal axis indicates the percentage of skilled workers in 2000; and the vertical axis is the average housing price growth rate from 2000 to 2010. The straight line is the linear fixed value.

Figure 4: Migrant Workers Move into Skilled Cities

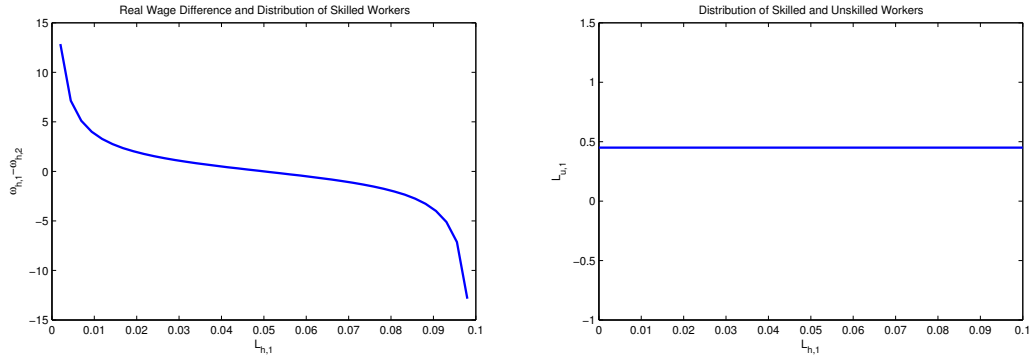


Note: The horizontal axis indicates the percentage of skilled workers in 2000; and the vertical axis is the migrant worker indicator in 2010. It is defined as the ratio of total population over registered population (with "Hukou"). The straight line is the linear fixed value.

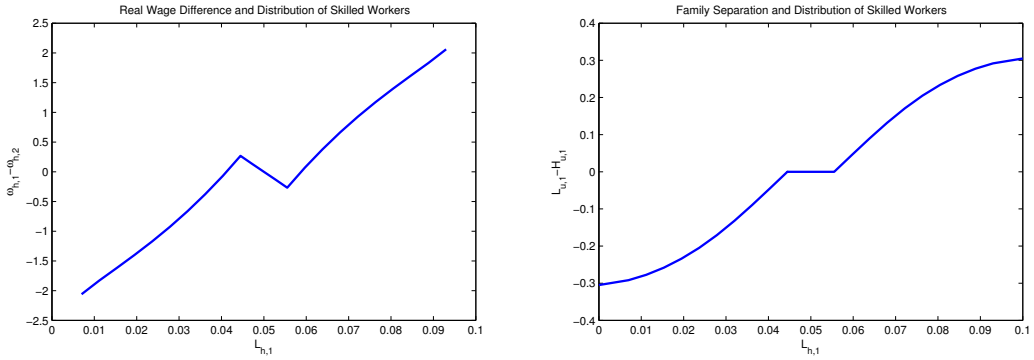
Figure 5: Simulation Results



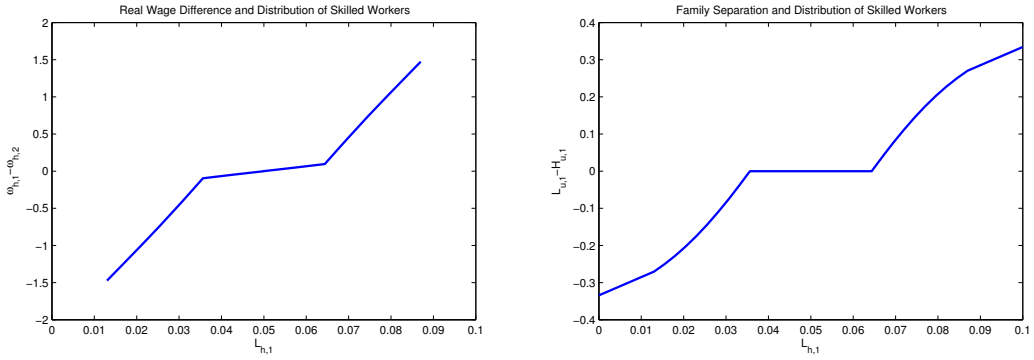
(a) Scenario 1



(b) Scenario 2



(c) Scenario 3



(d) Scenario 4

Figure 6: Effects of Housing Supply Elasticity

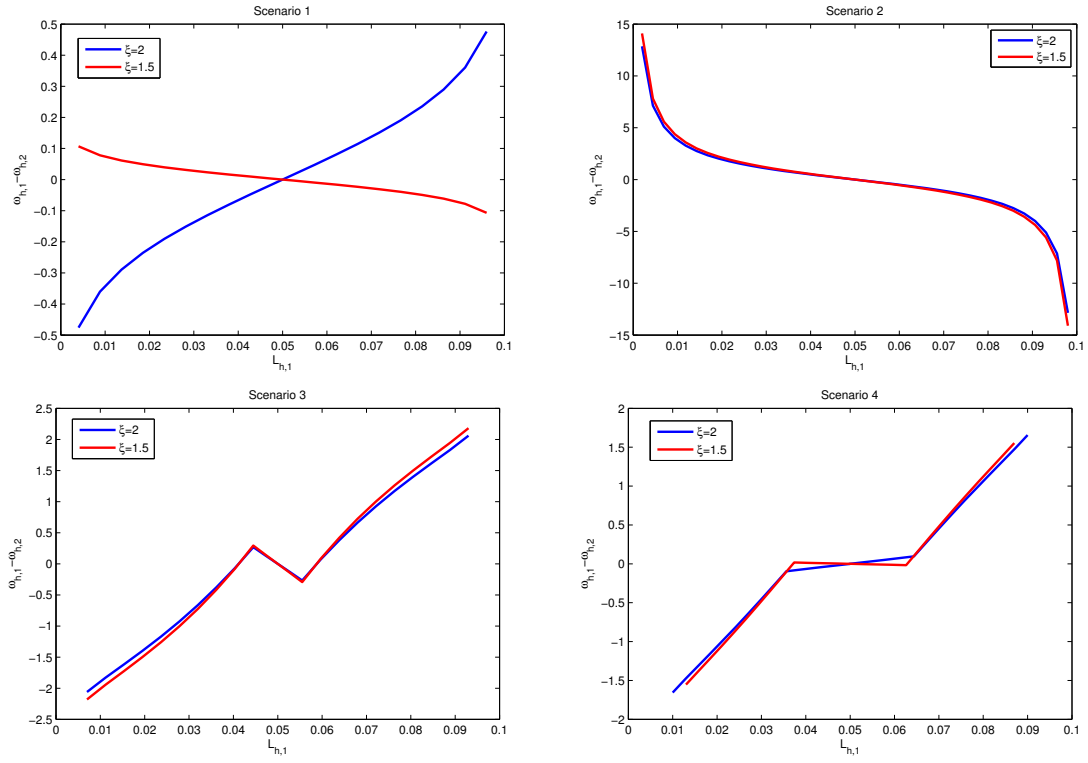


Figure 7: Effects of Knowledge Spillovers