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TO STAY OR TO MIGRATE? WHEN BECKER MEETS HARRIS-TODARO

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ABSTRACT

Allowing migration activity as an integral part of demographic transition and economic development, we establish a locational quantity-quality trade-off of children and explore its macroeconomic consequences. We construct a dynamic competitive migration equilibrium framework with rural agents heterogeneous in skills and fertility preferences. We then establish and characterize a mixed migration equilibrium where high-skilled rural agents with low fertility preferences always migrate to cities, low-skilled with high fertility preferences always stay, and only an endogenously determined fraction of high-skilled/high fertility preferences or low-skilled/low fertility preferences ends up moving. By calibrating our model to fit the data from China, we find interesting interactions between fertility and migration decisions in various counterfactual experiments with respect to changes in migration, population control and rural land entitlement policies. We conclude that overlooking the locational quantity-quality trade-off of children may lead to nonnegligible biases in assessing the implications and effectiveness of government policies.

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1 Introduction

Fifty years ago, Todaro (1969) and Harris and Todaro (1970) provided solid foundation for studying the process of rural-urban migration commonly observed in developing countries. Thanking to the more recent contribution by Lucas (2004), there has been a vast interest in examining urbanization and structural transformation within a dynamic general equilibrium framework. While this renewed literature has generated useful insight toward understanding urban labor and housing issues as well as the macroeconomic consequences of rural-urban migration, the role of demographic transition played in the dynamic process of urbanization remains largely unexplored.

While it is relatively cheap to raise children in the countryside than in urban areas, cities are usually considered as a better location for children considering one's education and career opportunities. The chief purpose of this paper is to establish an internal migration model that incorporates such a *locational quantity-quality trade-off* of children. That is, we inquire, when Becker meets Harris-Todaro, whether the interplay of work-based rural-urban migration and fertility decisions may influence the macroeconomy of developing countries in the presence of large migration barriers and active population controls. In particular, our paper is devoted to addressing the following questions. What are the main channels through which work-based rural-urban migration and differential fertility decisions interplay in the process of economic development? What are the underlying macroeconomic and institutional factors driving such household decisions? What are the macroeconomic consequences of such interactions and the locational quantity-quality trade-off?

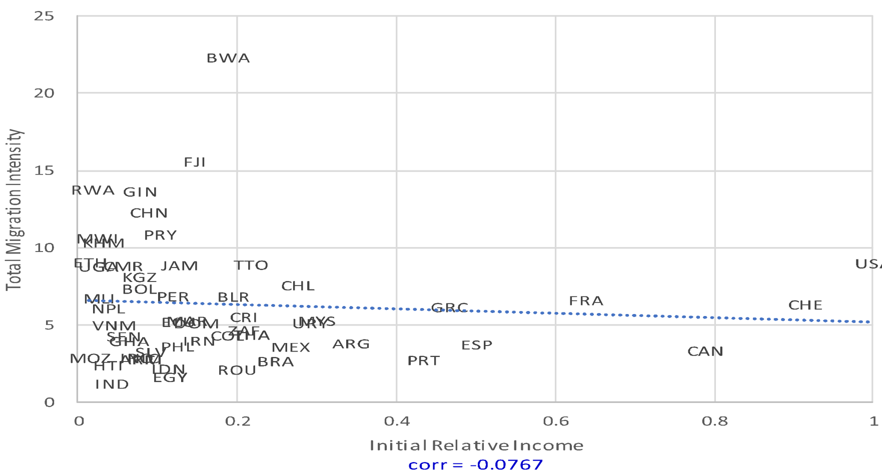
Based on merged data from Bernard, Bell and Cooper (2018), Penn World Table (PWT9.0), and the World Development Indicators (WDI), we observe the following cross-country patterns of internal migration and fertility, as shown in Figures 1a-1c.

- (Stylized Fact 1) Migration intensities (defined as total migrants as a ratio of total population aged 15 and above) are higher in less developed countries with lower initial relative income (relative to the U.S.).
- (Stylized Fact 2) Total fertility rates are higher in less developed countries with lower initial relative income.
- (Stylized Fact 3) In less developed countries, age at migration peak is younger, with many aged 22 or below.

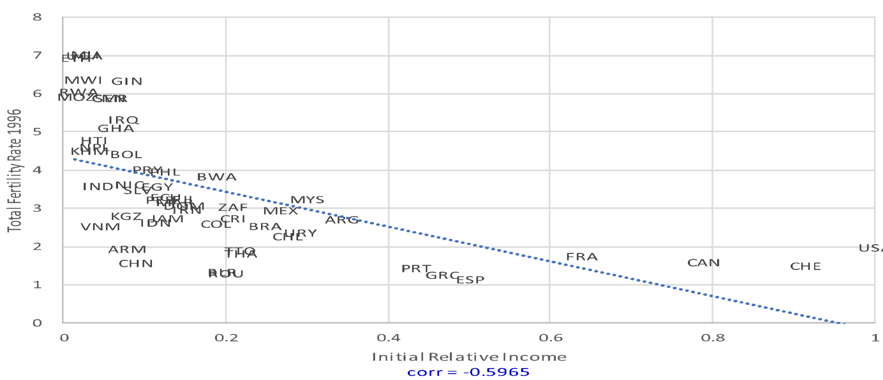
Because the migration intensity data in Bernard, Bell and Cooper (2018) is based on census data from sample countries over the period of 1996-2011, the span of our data analysis is set from 1996 to 2015. To measure development stage of various countries, we choose the U.S. as the benchmark and compute initial relative income as the real GDP per capita of a country relative to that of the U.S. in 1996. Figures 1(a) and 1(b) plot the patterns of migration intensity and the total fertility rates of 1996 against initial relative income in 1996. While migration intensity decreases with the relative income in 1996, with a correlation coefficient of -0.0767, TFR declines more sharply in initial relative income, with a correlation coefficient of -0.5965. In Figure 1(c), we see that age at migration peak is younger and rising as a country becomes more developed. For countries with relative income at or below 20% of the U.S., ages at migration peak are mostly 25 or under, with many at 22 or below.

Figure 1: Initial Relative Income, Migration Intensity, and Total Fertility Rate

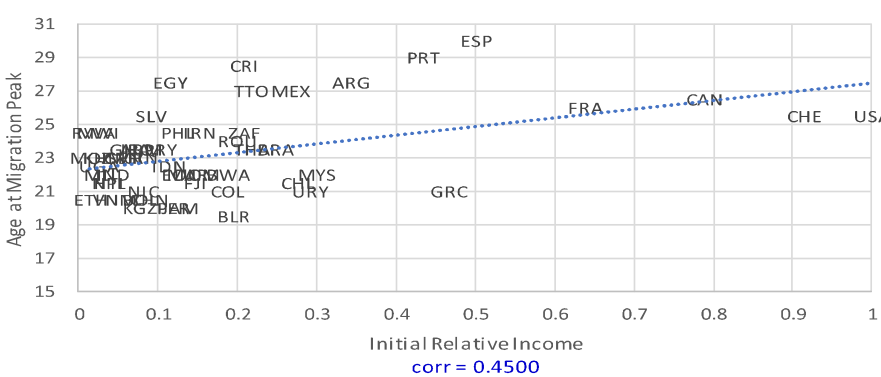
(a) Migration Intensity



(b) Total Fertility Rate



(c) Age at Migration Peak



These stylized facts suggest that migration and fertility decisions are both related to the stage of development, with less advanced featuring higher fertility and more intensive internal migration to urban areas at young ages. In other words, migration activity is an integral part of demographic transition and economic development, thereby motivating the present paper. So what are the costs and benefits associated with rural-urban migration? The major costs crucial for the interplay of migration and fertility are pecuniary and time cost associated with migration, the opportunity cost associated with lost rural earning and farm land use rights and the higher childrearing cost in urban areas. Such migration is beneficial, however, because of better pay and job perspectives, as well as better education and future for children and better urban amenities net of urban congestions/pollution and its rising cost of leaving. Should the marginal benefit exceed the marginal cost, rural workers are expected to continue migrating to cities. Since both the accrued cost and the opportunity cost of childrearing are high in urban areas, a consequence of such migration decision is a reduction in childbearing in conjunction with an improved quality of living locationally.

While the basic story mentioned above is simple and intuitive, to formalize it in a dynamic model with fertility and locational choice by heterogenous agents is by no means straightforward. To enable the analysis in a tractable and quantifiable manner, we thus impose various simplifying structures. First, as shown in Stylized Fact 3, migrations in developing countries occur at young ages. We thus assume that migration decision is made at the early stages of one's life. To avoid complicated overlapping-generational transitions in the presence of heterogenous agents, we set up a one-period lived non-overlapping generations framework with bequests, à la Aghion and Bolton (1997), under which there is no within-generation consumption-saving trade-off but a time-invariant fraction of lifetime income is transferred across generations over time. We further assume that children inherit the skill level and residency from parents and prohibit reverse migration from urban to rural. With this simplified structure, we are able to characterize the dynamic competitive migration equilibrium even by allowing agents to have two-dimensional heterogeneities in skills (high or low) and in fertility preferences (high or low) and by allowing the economy to be subject to various frictions and population policies.

We establish conditions to support a most plausible "mixed migration equilibrium" in the steady state: Those high-skilled rural residents with low fertility preferences always desire to migrate to cities, those low-skilled rural residents with high fertility preferences always stay in rural, and only an endogenously determined fraction of those high-skilled with high fertility preferences or low-skilled with low fertility preferences ends up moving. In a less developed economy under proper regularity conditions, we show that the fraction of movers of those high-skilled with high fertility preferences is lower than that of those low-skilled with low fertility preferences. The moving fraction differential shrinks when there is a tightened population policy that binds agents with high fertility preferences.

Just how important is the locational quantity-quality trade-off of children for economic development? To address this quantitative question, we calibrate our model economy to fit the data from China, which is particularly interesting because of its migration and population policies. These policies include the household registration system (called *hukou* that imposes large barriers on rural-urban migration), the differential one-child policy (with stronger enforcement in cities and in public sectors), and the rural land entitlement policy (that regulates the retention of its use rights by migrants and hence affects the incentive to migrate from rural to urban). These three policies allow us to perform several interesting policy experiments and counterfactual analyses, to assess migration, fertility and macroeconomic consequences of migration, population control and rural land entitlement policies. In all cases, we find that the locational quantity-quality trade-off of children plays a crucial role for economic development where more rural-urban migration is accompanied by lower fertility but higher overall per capita output. In response to changes in population control policies, there is a negative association between overall per capita output and skill premium; in response to changes in migration and land policies, however, such association turns to positive.

More specifically, our findings of completely removing population control are in line with the pure fertility choice model of Liao (2013): Skill premium increases and fertility rebounds, especially the fertility of those who were seriously affected by population control policies. By allowing rural-urban migration, our results further indicate that the increase in fertility is accompanied by lower migration – especially a larger reduction in the high-skilled migration and thereby a lower overall output per capita. Overall, relaxing urban population control to the rural level is better than entirely removing population control as it induces more high-skilled migration, leading to higher urban output and overall output per capita. Stricter population control policies in urban areas may not be ideal in lowering fertility rates from a nationwide perspective because such a tightened fertility policy in urban deters high-skilled workers with stronger fertility preferences from migrating to cities. This is undesirable because had they migrated to urban areas and faced a higher child-rearing cost, they would have naturally adjusted their fertility down. Moreover, we find that urban sprawl control policy such as eliminating urban benefit to all rural migrants will raise urban benefit as planned but would severely deter the incentives for rural-urban migration, which is undesirable for advancing the economy. Urban promotion policy such as providing full benefit to all rural migrants would induce more migration overall but suffer "adverse-selection" by motivating much more low-skilled but less high-skilled to migrate. Finally, with more generous rural land entitlement, migration incentives are stronger. While rural per capita output is lower due to migrants' land entitlement and urban per capita output decreases due to migration of more low-skilled workers, the aggregate per capita output is higher due to urban wage premium – a result that is possible because of the endogenous population weight due to rural-urban migration.

Summarizing, the main takeaway is that, when formulating policies for developing countries, one shall not neglect policy impacts via migration and fertility responses. Ignoring the locational quantity-quality trade-off of children and overlooking such trade-off may lead to nonnegligible biases in assessing the consequences and effectiveness of government policies.

Literature Review Previous works on reallocating abundant and over-employed labor from rural agricultural sector to urban manufacturing sector can be traced back to the Lewis (1954). The research focusing on rural-urban migration was pioneered by Todaro (1969) and Harris and Todaro (1970). Since then, economists have attempted to understand the forces driving rural to urban migration and the impacts of rural-urban migration on development process.

There are some related studies examining the causes and consequences of rural-urban migration using calibrated dynamic models. The pivotal study is by Lucas (2004) who proposes that human capital accumulation in cities induces better earnings and hence migration from rural to urban areas. Rural-urban migration ceases when the values of earnings in the two locations equalize. Laing, Park and Wang (2005) build a dynamic search model to illustrate how reductions in urban labor market frictions may yield higher wage and induce more rural-urban migration. By constructing a surplus labor framework, Bond, Riezman and Wang (2016) find sizable effects of reductions in trade and migration barriers on China's growth and urbanization. Liao, Wang, Wang and Yip (2017) study the rural-urban migration in China with a focus on education-based migration and establish that the contribution of education-based migration on urban output shares are comparable to that of work-based migration. Garriga, Hedlund, Tang and Wang (2017) show that the housing boom in China is essentially driven by urban TFP induced rural-urban migration, amplified by migration barriers reductions. Ngai, Pissarides and Wang (2019) illustrate how much the household registration system in China has slowed down industrialization and urbanization in China. For a comprehensive review of the literature of internal migration from a macro perspective, the reader is referred to Lagakos (2020).

To our best knowledge, this paper is the first to examine rural-urban migration with endogenous fertility choice within a dynamic general equilibrium framework. Not only are we able to infer decision rules of migration for agents with heterogenous skills and preferences toward children, we can also quantify how much migration and population policies may affect rural-urban migration and economic development.

2 The Model

As discussed in the introduction, migration intensities and total fertility rates are higher in less developed countries with many migrating at young ages. Our model will be built upon these facts. To allow for policy analysis, our model will incorporate a rich array of migration and fertility related policies prevalent in developing countries.

Consider an infinite horizon model of one-period-lived agents and two geographical locations, urban and rural. In rural areas, production is simply backyard farming, using land as an input. There are two sectors in cities: a private sector (P) and a public sector (S) that contains government agencies and public enterprises. While workers in the public sector all hold urban residency, the private sector employees may not. Urban workers with urban residency are entitled with urban benefits, whereas rural farmers are entitled with the use rights of rural land as often observed in developing countries under various usage and zoning restrictions such as regulations imposed on agricultural land.

As agents make migration decisions within the one period of their lifetime, in any location or sector, the beginning-of-the-period population and the actual-working population stocks are different, with the differences resulting from the net migration flows of workers. To avoid confusion, the number of workers actually working in the sector during a period *after migration occurs* is distinguished by a superscript "+". We use the subscript t to index time and dismiss it whenever it does not lead to confusion.

Agents live for one period, and are heterogeneous in skill levels and fertility preferences. There are two different skill levels, high (H) and low (L), and two types of fertility preferences (β), high ($\beta = \bar{\beta}$) and low ($\beta = \underline{\beta}$), with the high type in favor of having more children. Children inherit skills and residency status from parents, but the preferences toward children are assumed to be redrawn for every generation. Agents consume and give births to n children right before the end of their life. They are altruistic, deriving utility from both the quantity and quality of children, owning one unit of labor time and supplying labor inelastically throughout their life.

In the following, we will first describe the sectoral production in the economy, and study the household optimization problems in urban and rural areas. Once we define the value functions of the agents, we then delineate how rural agents make migration decisions to urban sectors. Finally, we discuss the evolution of workers and study the equilibrium of the economy.

2.1 Production

We begin with rural production, followed by the two sector production activities in urban areas.

2.1.1 Rural production

Rural land is constant over time at a level Q and its use rights are evenly distributed to rural workers at the beginning of each period. Rural production uses land as inputs, requires workers to stay on site to operate the production technology but does not require skills. Denote R as the beginning-of-the-period farmers in rural areas and R^+ as the mass of farmers residing on the rural land during a period after migration occurs. For migrants moving to cities and leaving their land behind, they retain their entitlement of land for $\delta \in [0, 1]$ fraction of lifetime before losing it. The use rights of the idle land will then be evenly reallocated to farmers staying in rural areas. Total output in rural area is:

$$X = zQ\left(1 - \tilde{\delta}\right), \tag{1}$$

where $z > 0$ is the farming technology and $\tilde{\delta} \equiv (R - R^+)\,\delta/R$ is the fraction of land left idle out of total land. Define $q \equiv Q/R$ as the beginning-of-the-period land per farmer. Rural workers' per capita income is given by,

$$x \equiv \frac{X}{R^+} = zq\left[1 + \frac{(R - R^+)\,(1 - \delta)}{R^+}\right], \tag{2}$$

where the first term in the bracket times by q is the initially-distributed land, and the second term times by q is the extra land obtained during the period from land reallocation.

2.1.2 Urban production

There are two types of firms in urban areas: public enterprises and private firms. Public enterprises operate a linear technology, taking relatively high-skilled workers as inputs to produce output. The technology is given by,

$$Y_S = A_S S^+, \tag{3}$$

where A_S is the technology scaling factor of public enterprises, and S^+ is the number of high-skilled workers hired by public enterprises.

Unlike public enterprises, private firms hire both high- and low-skilled workers in production. Denote P^{H+} and P^{L+} as the quantity of high- and low-skilled workers hired by private firms The production of private firms takes the following CES form:

$$Y_P = A_P \left[\alpha \left(\eta P^{H+}\right)^{\sigma} + (1-\alpha)\left(P^{L+}\right)^{\sigma}\right]^{\frac{1}{\sigma}}, \quad \eta > 1,\, \alpha \in (0,1)\,,\, \sigma < 1, \tag{4}$$

where A_P is the technology scaling factor of private firms, η is the quality index of high-skilled workers that captures the relative productivity of the high- to the low-skilled, α is the share parameter, and $1/(1-\sigma)$ is the elasticity of substitution between the high- and low-skilled workers in production. Under competitive markets, the wage rates in public enterprises and private firms are:

$$w_S = A_S, \tag{5}$$

$$w_P^H = A_P \left[\alpha \left(\eta P^{H+}\right)^{\sigma} + (1-\alpha)\left(P^{L+}\right)^{\sigma}\right]^{\frac{1}{\sigma}-1} \alpha\eta^{\sigma}\left(P^{H+}\right)^{\sigma-1}, \tag{6}$$

$$w_P^L = A_P \left[\alpha \left(\eta P^{H+}\right)^{\sigma} + (1-\alpha)\left(P^{L+}\right)^{\sigma}\right]^{\frac{1}{\sigma}-1} (1-\alpha)\left(P^{L+}\right)^{\sigma-1}. \tag{7}$$

It is straightforward to derive the wage ratio:

$$\frac{w_P^H}{w_P^L} = \frac{\alpha}{1-\alpha}\eta^{\sigma}\left(\frac{P^{H+}}{P^{L+}}\right)^{-(1-\sigma)}, \tag{8}$$

which depends negatively on the employment ratio but positively on the quality of high-skilled workers. Define $\left(\frac{P^{H+}}{P^{L+}}\right)_{\max} \equiv \left(\frac{\alpha}{1-\alpha}\eta^{\sigma}\right)^{\frac{1}{1-\sigma}}$. To ensure positive skill premium, equilibrium labor market must be subject to the following restriction under which high-skilled workers earn at least as much as low-skilled workers in the same sector:

Condition 1 $\frac{P^{H+}}{P^{L+}} \leq \left(\frac{P^{H+}}{P^{L+}}\right)_{\max}$.

Finally, because workers in the S sector enjoy a higher level of the urban benefit than those in the P sector, there is a public-sector discount in the relative wage, i.e., $w_S/w_P^H < 1$. This issue will be discussed further in the subsection 2.2.2.

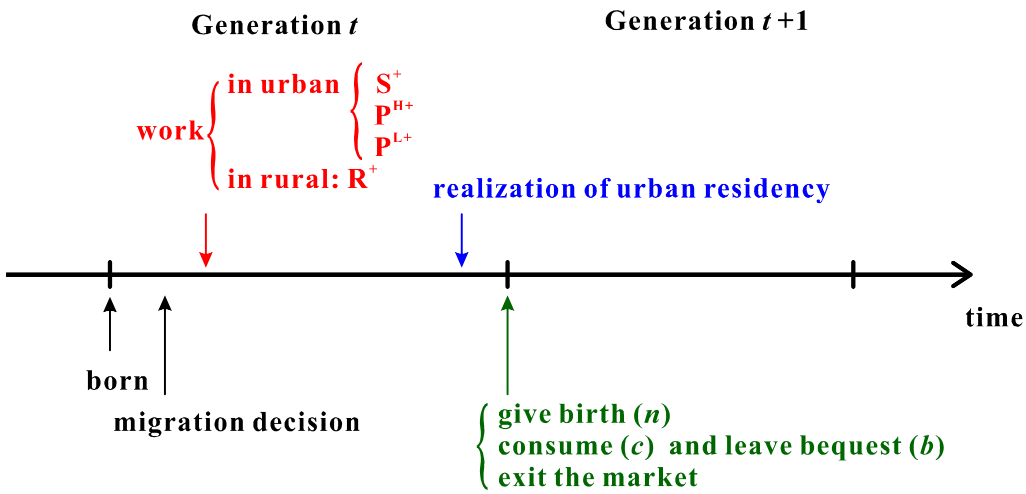
2.2 Households

All agents live for one period and have perfect foresight. As mentioned previously, agents are born to be different in their skill levels and preferences toward children and inherit the skill levels and residency status from their parents. Below the lifetime of rural households is described first, followed by the description for urban households.

2.2.1 Rural agents

Due to its small magnitude in developing countries at the stage of relatively low urbanization, reverse migration from urban to rural areas is ruled out in our model.[1] For agents born in rural areas, they choose whether to migrate to cities immediately after they were born. If the expected value of staying in the rural area is higher than the expected value of migrating to cities, agents will choose to stay in the rural area; vice versa. After the migration decision, agents work in the chosen location throughout their lifetime. If the agent has moved to cities, urban residency may be granted after a certain duration, that entitles the agent to enjoy urban benefits. Before the end of life, agents give birth to children subject to the fertility quota or subsidy imposed by the government – if there is any. After giving births to children, agents consume, incur child rearing costs, pay the above-quota penalty or receive per child subsidy, and then exit the market. Figure 2 depicts the timeline of a rural agent's life.

Figure 2: Timeline



Denote c as consumption and b as the bequest left for each child. The utility of a rural worker staying in rural areas is:

$$u^R(c, b, n; \beta) = \min[\theta c, (1-\theta) nb] + \beta n^{\varepsilon}, \quad \varepsilon \in (0, 1), \tag{9}$$

where $\theta \in (0,1)$ is the altruistic factor, which is proportional to the net income allocating to total bequests; $\beta \in \{\underline{\beta}, \bar{\beta}\}$, with $0 < \underline{\beta} < \bar{\beta}$, captures an agent's preference toward children and measures how one values children. β is re-drawn at birth for every generation: With a probability ζ, an agent enjoys less from having children ($\beta = \underline{\beta}$), and with a probability $1-\zeta$, an agent enjoys more from

[1] The evidence provided by Lucas (2004, Table 1) argues that the main trend of internal migration is from rural to urban for a selected group of representative countries in the last half of the twentieth century. In addition, reverse migration would not add any insights unless one allows for heterogeneous locational preferences or heterogeneous sectoral productivities – without such heterogeneities, only net migration flows matter.

having children ($\beta = \bar{\beta}$). As the agent is one-period lived, the Leontief setting in c and nb is meant to capture the consumption-saving decision, with nb acting as total saving in offsprings. Given the one-period setting of the model, we do not connect b directly to the productivity of the child but instead considered it as the cost of establishing good attributes of children – a quality dimension under this bequest setting with b capturing investment in each child.

Having children is costly. Assume that child rearing cost is ϕ_R^0 per child in rural areas. There are two types of fertility policies under our consideration. One is related to direct population control whereas another is to childrearing subsidy. For simplicity, both cases are modeled in the quantity aspect, which enables us to use a single variable $\bar{n}_R$ to capture either the fertility quota under control or the minimum number of children qualified for childrearing subsidies. Under direct population control, the government imposes an above-quota fine of $\bar{\phi}_R > 0$ per child, so the total penalty payment is $(n - \bar{n}_R) \cdot \bar{\phi}_R$. Under childrearing subsidy, the government provides $-\bar{\phi}_R > 0$ of per child subsidy, giving a rural worker a total subsidy of $(n - \bar{n}_R) \cdot \left(-\bar{\phi}_R\right)$. With an income x from farming, the budget constraint of a rural worker under either scenario is then:

$$c + nb + n\phi_R^0 + \max\{n - \bar{n}_R, 0\}\,\bar{\phi}_R = x. \tag{10}$$

A rural agent's problem is thus to choose $\{c, b, n\}$ to maximize lifetime utility (9) subject to the budget constraint (10).

2.2.2 Urban agents

Similar to rural agents, urban agents derive utility from consumption (c), quality of children (b) and number of children (n). Urban residents may also enjoy urban benefits (B) such as urban amenities, medical services, public transportation subsidies, allowances for the elderly and etc. However, only residents with urban residency are qualified for these benefits, and at the same time they need to pay an embarked tax τ to finance these benefits. For rural migrant workers arriving at the cities without urban residency, they have a probability ρ to obtain urban residency which entitles them with urban benefits for μ fraction of their lifetime upon paying the urban embarked tax τ. As migrant workers may start their career in cities with or without urban residency, and some migrant workers may obtain urban residency later, we need two indicator functions I^F and I^T to indicate the urban residency status of an urban worker:

$$I^F = \begin{cases} 1, & \text{if the agent holds urban residency when starting working,} \\ 0, & \text{if the agent does not hold urban residency when starting working.} \end{cases}$$

$$I^T = \begin{cases} 1, & \text{if the agent successfully obtains urban residency despite } I^F = 0 \text{ initially,} \\ 0, & \text{if the agent fails to obtain urban residency despite } I^F = 0 \text{ initially.} \end{cases}$$

Depending on the status of urban residency, an urban worker enjoys (pays) urban benefits (taxes) of B (τ), μB ($\mu\tau$) or nothing.

Let superscript U denote urban workers regardless of their urban residency status. An urban worker has the following utility function:

$$u^U(c,b,n,B;\beta)|_{I^F,I^T} = \min[\theta c,(1-\theta)nb] + \beta n^\varepsilon + \left[I^F + \left(1-I^F\right)I^T\mu\right]B. \tag{11}$$

Denote $\bar{n}_U$ as the fertility quota or the minimum number of children to be eligible for urban child-rearing subsidies for agents with urban residency. Two remarks are in order. First, as to be clarified below, we will consider a nondegenerate case where the fertility quota are binding for some but not all of the agents. Second, urban childcare is more expansive than rural whereas urban workers get penalized more than rural when giving birth to above-quota number of children. Let ϕ_U^0 be the childrearing cost in urban areas, $\bar{\phi}_U$ be the urban above-quota penalty or per child subsidy. That is, we restrict our attention to the case of $\phi_U^0 > \phi_R^0$ and $\bar{\phi}_U \geq \bar{\phi}_R$.

Denote $w \in \{w_S, w_P^H, w_P^L\}$ as workers' wage income from working in either the public sector or the private sector by their skill levels. An urban worker's budget constraint is:

$$\begin{aligned} & c + nb + n\phi_U^0 + \left[I^F + \left(1-I^F\right)I^T\right]\max\{n-\bar{n}_U,0\}\bar{\phi}_U \\ & + \left[1 - \left[I^F + \left(1-I^F\right)I^T\right]\right]\max\{n-\bar{n}_R,0\}\bar{\phi}_R \\ = \; & w - \left[I^F + \left(1-I^F\right)I^T\mu\right]\tau \equiv \tilde{w}, \end{aligned} \tag{12}$$

where $\tilde{w}$ denotes urban net (of tax) wage that depends on the urban residency status. All urban workers face the same child-rearing costs regardless of their residency status, albeit the benefits and obligations are associated with one's residency. So an urban worker with urban residency $\left(\left(I^F=1,I^T=0\right) \text{ or } \left(I^F=0,I^T=1\right)\right)$ faces a budget constraint that can be rewritten as:

$$c + nb + n\phi_U^0 + \max\{n-\bar{n}_U,0\}\bar{\phi}_U = \tilde{w}. \tag{13}$$

On the other hand, the budget constraint of an urban worker with rural residency $\left(\left(I^F,I^T\right)=(0,0)\right)$ is:

$$c + nb + n\phi_U^0 + \max\{n-\bar{n}_R,0\}\bar{\phi}_R = w. \tag{14}$$

Before moving to the migration decision, we identify the link between fertility preference (β) and fertility constraint ($\bar{n}_j$). Denote n_j^* as the optimal fertility choice of an agent in location j ($j=U,R$). We are interested in the nondegenerate case: Agents with high fertility preferences ($\beta=\bar{\beta}$) will have $n_j^* > \bar{n}_j$ in which the fertility constraint is binding; those with low fertility preferences ($\beta=\underline{\beta}$) will have $n_j^* < \bar{n}_j$ and the fertility constraint is not binding. We summarize this relation by using an indicator function I^β ($\beta=\bar{\beta}$) below, where

$$I^\beta = \begin{cases} 1, & \text{for agents with high fertility preferences } (\beta=\bar{\beta}), \\ 0, & \text{for agents with low fertility preferences } (\beta=\underline{\beta}). \end{cases}$$

2.3 Rural-Urban Migration Decision

For workers born in rural areas, they decide whether to migrate to cities by comparing the value of staying in rural areas to that of migrating to urban areas. Based on their endowed skill levels and preferences toward children, their expected values of migrating to urban areas are different. For high-skilled workers, they have a chance to work in the public sector that grants them with urban residency immediately. If they fail to obtain a job in the public sector, they work as high-skilled workers in the private sector with rural residency; after staying in cities for a certain duration, they have a chance to obtain urban residency. Low-skilled workers are only competent for low-skilled jobs in the private sector, and also have a chance to obtain urban residency. For those obtaining urban residency successfully, they enjoy urban benefits and are obligated to regulations coming with urban residency.

In the following, we characterize rural workers' migration decision by first defining the value functions of staying in rural areas, working in the public sector and working in the urban private sector for both high- and low-skilled workers. We will then establish the conditions under which a rural worker decides to migrate to cities.

2.3.1 Value function of staying in rural areas

The value function for rural agents to stay in rural areas is independent of their skill levels:

$$\begin{aligned} V^R(\beta) &= \max_{c,b,n} u^R(c,b,n;\beta) \\ &= \max_{c,b,n} \{\min[\theta c, (1-\theta)nb] + \beta n^{\varepsilon}\} \\ s.t. \quad & c + nb + n\phi_R^0 + \max\{n - \bar{n}_R, 0\}\bar{\phi}_R = x. \end{aligned}$$

To solve $V^R(\beta)$, from the Leontief preference in c and nb, we substitute $c = \frac{(1-\theta)}{\theta}nb$ into the budget constraint, where it is now clear that the altruistic factor θ is the fraction of income allocated to bequest. The maximization problem becomes:

$$\begin{aligned} V^R(\beta) = \max_{b,n} \quad & (1-\theta)nb + \beta n^{\varepsilon} \\ s.t. \quad & \frac{1}{\theta}nb + n\phi_R^0 + \max\{n - \bar{n}_R, 0\}\bar{\phi}_R = x, \end{aligned}$$

where $\varepsilon < 1$. Denote λ as the Lagrangian multiplier associated with the budget constraint. The first-order conditions for n and b are:

$$(1-\theta)b + \varepsilon\beta n^{\varepsilon-1} = \lambda\left(\frac{1}{\theta}b + \phi_R^0 + I^{\beta}\bar{\phi}_R\right), \tag{15}$$

$$(1-\theta)n = \frac{\lambda}{\theta}n. \tag{16}$$

Using (16) and (15) to substitute out $\lambda = \theta(1-\theta)$ with the fact that the marginal cost (MC) and marginal benefit (MB) from bequests exactly cancel out with each other under Leontief preferences, we obtain a key expression for fertility decision:

$$\underbrace{\frac{\varepsilon\beta}{n^{1-\varepsilon}}}_{\text{MB of fertility}} = \underbrace{\theta(1-\theta)\left[\phi_R^0 + I^{\beta}\bar{\phi}_R\right]}_{\text{MC of fertility}}, \tag{17}$$

where the left-hand-side and the right-hand-side of the above equation are the MB and MC from having an extra children, respectively. With normality, an increase in the altruistic factor that raises bequest should suppress fertility. As a result, we impose the following condition on θ:

Condition 2 $\theta < 1/2$.

From (17), it is thus straightforward to derive:

Proposition 1. (Rural Fertility Choice) *The optimal rural fertility rate (n_R^*) is increasing with preference for children (β), decreasing with the altruistic factor (θ) or the unit childrearing cost (ϕ_R^0), and independent of income (x). Moreover, while an above-quota fine ($\bar{\phi}_R > 0$) discourages fertility, a childrearing subsidy ($\bar{\phi}_R < 0$) encourages it.*

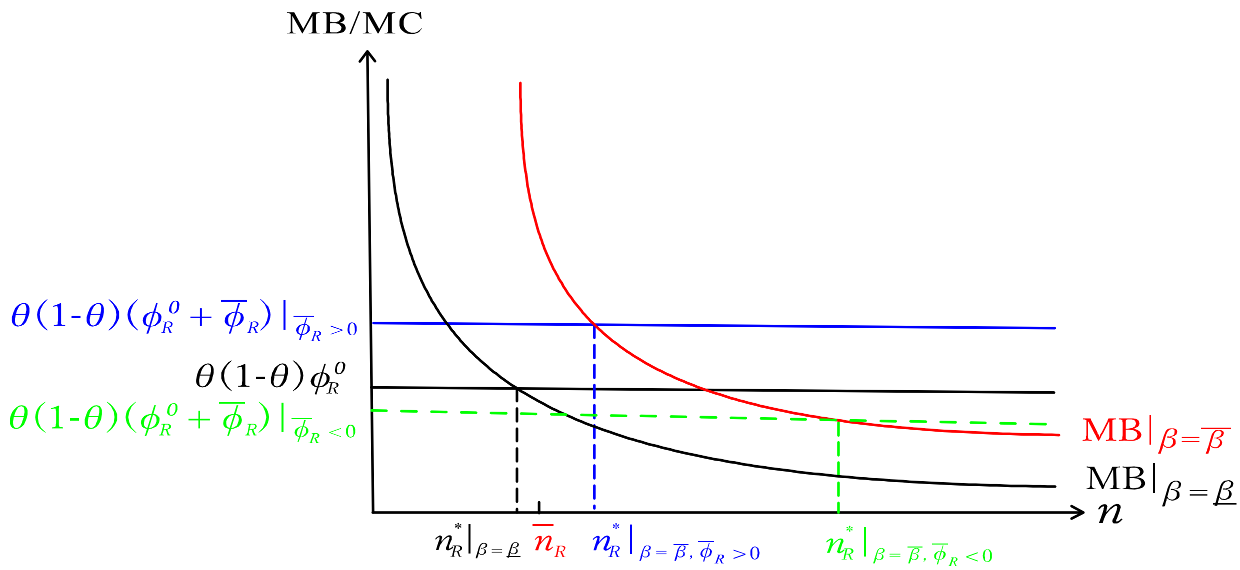
Similar to quasi-linear preferences, a nice property associated with Leontief preferences is that the optimal number of children n_R^* is independent of agents' income and wealth. This enables us to focus exclusively on the typically stronger substitution effect.

It is informative to plots the MB and the MC curves of fertility decision in Figure 3. Based on the results in Proposition 1, the MB curve of agents with $\bar{\beta}$ lies to the right of the MB curve of agents with $\underline{\beta}$, meaning that agents with stronger fertility preferences will choose to have more children than those with weaker preferences. As mentioned before, below we will focus on the relevant case where the government's population policy is only binding for agents with stronger fertility preferences. This is an interesting case to look at because agents with $\underline{\beta}$ choose $n_R^*|_{\underline{\beta}} \leqslant \bar{n}_R$ whereas agents with $\bar{\beta}$ choose $n_R^*|_{\bar{\beta}} > \bar{n}_R$, by paying the above-quota penalty or receiving childrearing subsidy. To guarantee that $n_R^*|_{\bar{\beta}} > \bar{n}_R$ under $\beta = \bar{\beta}$, we impose a condition derived from (17):[2]

Condition 3 $\bar{n}_j < \left[\frac{\varepsilon\bar{\beta}}{\theta(1-\theta)\left[\phi_j^0 + I^{\beta}\bar{\phi}_j\right]}\right]^{\frac{1}{1-\varepsilon}}, \quad j = R, U.$

As a result, the case under our consideration features: $n_R^*|_{\bar{\beta}} > \bar{n}_R \geq n_R^*|_{\underline{\beta}}$, as drawn in Figure 3.

Figure 3: Determination of Fertility for Rural Workers



[2] We note that Condition 3 is general and can apply to both locations, rural and urban.

We can solve n_R^* analytically from (17) as:

$$n_R^* = \left[\frac{\varepsilon\beta}{\theta(1-\theta)\left[\phi_R^0 + I^\beta \bar{\phi}_R\right]} \right]^{\frac{1}{1-\varepsilon}}. \tag{18}$$

The optimal bequest or children's quality b^* can then be solved from the budget constraint (10) as:

$$b^* = \theta \left[\frac{x}{n_R^*} - \phi_R^0 - I^\beta \left(1 - \frac{\bar{n}_R}{n_R^*}\right) \bar{\phi}_R \right]. \tag{19}$$

Under our setting, total bequest is a constant share of "disposable income" at the end of one's lifetime after government transfers (fine or subsidy) and childrearing spending (measured by $x - n\phi_R^0 - \max\{n - \bar{n}_R, 0\}\bar{\phi}_R$). Thus, the quantity-quality trade-off is obvious: Higher quantity of children n_R^* is associated with lower quality measured by b^*. Although this dimension of quantity-quality trade-off is not the emphasis of our paper, it can be combined with Proposition 1 to imply:

Proposition 2. (Rural Quality Investment Choice) *Optimal investment in the quality of children (b^*) rises with income (x) and is negatively associated with the quantity of children (n_R^*). The quantity-quality trade-off is stronger in the presence of an above-quota fine ($\bar{\phi}_R > 0$) but weaker in the presence of a childrearing subsidy ($\bar{\phi}_R < 0$).*

That is, population controls tend to induce a stronger quantity-quality trade-off in fertility choice but childrearing incentives tend to weaken it.

With n_R^* and b^* being pinned down by (17) and (19), the value function $V^R(\beta)$ is solved as:

$$V^R(\beta) = (1-\theta)\theta \left\{ x - n_R^*|_\beta \left[\phi_R^0 + I^\beta \left(1 - \frac{\bar{n}_R}{n_R^*|_\beta}\right) \bar{\phi}_R \right] \right\} + \beta \left(n_R^*|_\beta\right)^\varepsilon.$$

2.3.2 Value functions of urban workers

We start with the urban private sector where main actions take place, followed by the urban public sector. In all cases, fertility choice retains similar functional form to the rural case, with rural income replaced by after tax wage ($\tilde{w}$), childrearing cost updated to the urban levels ϕ_U^0 and above-quota penalized or subsidized to $\bar{\phi}_U$. To save space, we shall not report these solutions but note that the properties in Propositions 1 and 2 will be carried out for all urban workers of different types in different sectors.

Value function of workers in the private sector

1. High-skilled workers

For high-skilled rural migrants working in the private sector, after staying in urban areas for $(1-\mu)$ of their lifetime, they obtain urban residency with a probability ρ ($I^F = 0$, $I^T = 1$). With a probability $(1-\rho)$, they fail to do so and hold rural residency throughout their life ($I^F = 0$, $I^T = 0$). Denote $V^{P,H}(\beta)$ as the value function of a high-skilled migrant worker in the private sector. $V^{P,H}(\beta)$, which can thus be written as:

$$V^{P,H}(\beta) = \rho \left\{ \begin{array}{c} \max\limits_{c,b,n} u^U(c,b,n;\beta)\,|_{I^F=0,I^T=1} \\ s.t.\ c + nb + n\phi_U^0 + \max\{n-\bar{n}_U, 0\}\bar{\phi}_U = w_P^H - \mu\tau \end{array} \right\} + (1-\rho) \left\{ \begin{array}{c} \max\limits_{c,b,n} u^U(c,b,n;\beta)\,|_{I^F=0,I^T=0} \\ s.t.\ \ c + nb + n\phi_U^0 + \max\{n-\bar{n}_R, 0\}\bar{\phi}_R = w_P^H \end{array} \right\}.$$

Because urban workers' fertility decisions depend on urban residency, we denote separately $n_F^*|_\beta$ and $n_I^*|_\beta$ as the number of children chosen by private sector workers with and without urban residency (i.e., by formal and informal private sector workers, respectively). Following the same steps as in the rural worker's optimization problem, we can solve:

$$n_F^*|_\beta = \left[\frac{\varepsilon\beta}{\theta(1-\theta)\left[\phi_U^0 + I^\beta\bar{\phi}_U\right]}\right]^{\frac{1}{1-\varepsilon}}$$

and

$$n_I^*|_\beta = \left[\frac{\varepsilon\beta}{\theta(1-\theta)\left[\phi_U^0 + I^\beta\bar{\phi}_R\right]}\right]^{\frac{1}{1-\varepsilon}}$$

Recall $n_R^*|_\beta$ from (18) and that $\phi_U^0 > \phi_R^0$ and $\bar{\phi}_U \geq \bar{\phi}_R$. It is straightforward to show that the urban fertility choices are always below the rural counterpart, with formal urban workers' fertility lower than informal urban worker's:

Proposition 3. (Comparison of Fertility Choices) $n_F^*|_\beta \leq n_I^*|_\beta < n_R^*|_\beta$.

Substitute the solutions of the maximization problem into the value function above. $V^{P,H}(\beta)$, $\beta = \{\underline{\beta}, \bar{\beta}\}$ can be written as:

$$V^{P,H}(\beta) = \rho \left\{ \begin{array}{c} (1-\theta)\theta\left\{w_P^H - \mu\tau - n_F^*|_\beta\left[\phi_U^0 + I^\beta\left(1 - \frac{\bar{n}_U}{n_F^*|_\beta}\right)\bar{\phi}_U\right]\right\} \\ +\beta\left(n_F^*|_\beta\right)^\varepsilon + \mu B \end{array} \right\} + (1-\rho) \left\{ \begin{array}{c} (1-\theta)\theta\left\{w_P^H - n_I^*|_\beta\left[\phi_U^0 + I^\beta\left(1 - \frac{\bar{n}_R}{n_I^*|_\beta}\right)\bar{\phi}_R\right]\right\} \\ +\beta\left(n_I^*|_\beta\right)^\varepsilon \end{array} \right\}.$$

2. Low-skilled workers

Denote $V^{P,L}(\beta)$ as the value function for low-skilled migrant workers in urban private sector, $\beta = \{\underline{\beta}, \bar{\beta}\}$. By applying the same procedure for deriving $V^{P,H}(\beta)$, we write $V^{P,L}(\beta)$ as:

$$V^{P,L}(\beta) = \rho \left\{ \begin{array}{c} (1-\theta)\theta\left\{w_P^L - \mu\tau - n_F^*|_\beta\left[\phi_U^0 + I^\beta\left(1 - \frac{\bar{n}_U}{n_F^*|_\beta}\right)\bar{\phi}_U\right]\right\} \\ +\beta\left(n_F^*|_\beta\right)^\varepsilon + \mu B \end{array} \right\} + (1-\rho) \left\{ \begin{array}{c} (1-\theta)\theta\left\{w_P^L - n_I^*|_\beta\left[\phi_U^0 + I^\beta\left(1 - \frac{\bar{n}_R}{n_I^*|_\beta}\right)\bar{\phi}_R\right]\right\} \\ +\beta\left(n_I^*|_\beta\right)^\varepsilon \end{array} \right\}.$$

Due to the absence of the income effect, low-skilled migrant workers' fertility choices resemble those of the high-skilled.

Value function of workers in the public sector

In many countries, working in the public sector requires a higher qualification, e.g. at least holding a high school diploma or passing certain government employee exams. We thus assume that only high-skilled workers can work in the public sector. For rural high-skilled agents migrating to cities, with a probability π they are recruited as public workers and are granted with urban residency immediately. They enjoy complete urban benefits and pay full urban taxes. With a probability $1-\pi$, they end up working in the private sector. A public sector worker has the following value function ($I^F = 1$):

$$V^S(\beta) = \max_{c,b,n} \left\{ \min\left[\theta c, (1-\theta) nb\right] + \beta n^{\varepsilon} + B \right\}$$

$$s.t. \quad c + nb + n\phi_U^0 + \max\left\{n - \bar{n}_U, 0\right\} \bar{\phi}_U = w_S - \tau.$$

By substituting in the number of children chosen and the investment in children quality, we obtain a public sector worker's value function $V^S(\beta)$, $\beta = \{\underline{\beta}, \bar{\beta}\}$:

$$V^S(\beta) = (1-\theta)\,\theta \left\{ w_S - \tau - n_F^*|_\beta \left[\phi_U^0 + I^\beta \left(1 - \frac{\bar{n}_U}{n_F^*|_\beta}\right) \bar{\phi}_U \right] \right\} + \beta \left(n_F^*|_\beta\right)^{\varepsilon} + B.$$

2.3.3 Migration decisions

We are ready to discuss agents' migration decisions. Migration is costly. To simplify the analysis, we assume that migration cost is in the form of utility. Depending on skill levels and preferences, rural workers may have different ability to adapt to urban life. Hence, we assume that moving from rural to urban areas takes a migration cost, $\psi \in \{\psi^L, \psi^H\}$, which is measured in utils, for low- and high-skilled agents, respectively. Should such migration cost in income-equivalent is proportional to earnings, one would expect that $\psi^H > \psi^L$.

Rural agents migrate to cities only if the expected value of migrating to urban areas is higher than the value of staying in the rural. Since high-skilled migrant workers have a probability π to obtain a job in the public sector and a probability $1-\pi$ to work in the private sector, high-skilled rural workers will migrate if the following inequality holds true:

$$\Delta V_H(\beta) \equiv \pi V^S(\beta) + (1-\pi) V^{P,H}(\beta) - \psi^H - V^R(\beta) \geq 0, \;\; \text{for } \beta \in \{\underline{\beta}, \bar{\beta}\}. \tag{20}$$

For low-skilled rural workers, they can only work in the private sector after migrating to urban areas. Hence, they will migrate to urban areas if the following inequality is met:

$$\Delta V_L(\beta) \equiv V^{P,L}(\beta) - \psi^L - V^R(\beta) \geq 0, \text{ for } \;\beta \in \{\underline{\beta}, \bar{\beta}\}. \tag{21}$$

When the above two equations are held with equality, rural agents are indifferent between migrating to urban areas and staying in rural areas. The migration decision thus depends on the relative magnitudes of rural income (x, which is a function of z, q, R^+ and δ) and urban incomes (w_S,

w_P^H, w_P^L), the relative child-rearing costs in urban and rural areas (ϕ_R^0 and ϕ_U^0), population policies (governed by $\bar{n}_R$, $\bar{n}_U$, $\bar{\phi}_R$ and $\bar{\phi}_U$), urban benefits (B), urban tax (τ), and easiness of obtaining urban residency and urban benefits (π, ρ and μ). Define an indicator function with $I^m = 1$ if rural-urban migration takes place, and $I^m = 0$ otherwise. Then we have:

$$I^m = \begin{cases} 1, & \text{iff } \Delta V_i(\beta) \geq 0, i = H, L, \\ 0, & \text{otherwise.} \end{cases} \tag{22}$$

There are four types of agents in the model: type-$\{H, \underline{\beta}\}$, type-$\{H, \bar{\beta}\}$, type-$\{L, \underline{\beta}\}$ and type-$\{L, \bar{\beta}\}$. Agents of different types will have different migration decisions depending on their preferences toward children and their income levels, and the model thus has several possible equilibrium outcomes. As a result, the evolution of workers and the supply of urban amenities under each of these equilibrium outcomes will also differ, which we now turn to discuss.

3 Equilibrium

Prior to defining the equilibrium, we delineate the concept of a mixed migration equilibrium that restricts our attention to a most plausible migration pattern, based on which we specify the evolution of workers and the supply of urban amenities. A dynamic competitive migration equilibrium is subsequently defined, followed by a steady-state migration equilibrium.

3.1 Mixed Migration Equilibrium

Generally speaking, high-skilled agents have higher motivation to migrate to cities than low-skilled workers as skills are more rewarding in urban areas. For low-skilled workers, it is usually the case in developing countries that wage incomes in cities are higher than the incomes from farming. However, the costs of raising children in terms of housing, spacing and tuitions are usually higher in cities, and agents who prefer to have more children may be more prone to stay in rural areas. Therefore, we choose to confine our attention to a specific migration equilibrium: Type-$\{H, \underline{\beta}\}$ workers always choose to migrate to cities, type-$\{L, \bar{\beta}\}$ always decide to stay in rural areas, whereas type-$\{H, \bar{\beta}\}$ and type-$\{L, \underline{\beta}\}$ agents are indifferent between migrating and staying so that some of them stay in rural areas while others migrate to cities. This is the most relevant case to study in developing countries at the stage of relatively low urbanization.

More precisely, denote Γ_H as the fraction of high-skilled workers with high fertility preference (i.e., type-$\{H, \bar{\beta}\}$) being indifferent between migrating and staying but ending up moving to cities, and $(1 - \Gamma_H)$ as the fraction of them staying in their rural hometown. Similarly, denote Γ_L as the fraction of the low-skilled workers with low fertility preference (i.e., type-$\{L, \underline{\beta}\}$) and indifferent between migrating to cities and staying in rural areas, but ending up moving to cities, and $(1 - \Gamma_L)$ as the fraction of them staying in rural areas. The migration patterns for high- and low-skilled workers of the equilibrium that we focus on can be best summarized below:

	$\underline{\beta}$ ζ of workers	$\bar{\beta}$ $(1-\zeta)$ of workers
H	move	Γ_H move $(1-\Gamma_H)$ stay
L	Γ_L move $(1-\Gamma_L)$ stay	stay

The detailed equilibrium conditions and the definition of the migration equilibrium are relegated to Section 3.4 below.

Note that if $0 < \Gamma_H < 1$ and $0 < \Gamma_L < 1$, we have the ***mixed migration equilibrium (MME)*** – "mixed" in the sense that both a positive fraction of high- and low-skilled workers migrate to cities in the equilibrium. If $\Gamma_H = 1$ and $0 < \Gamma_L < 1$, we have a skilled-based ***segregated migration equilibrium (SME)***: All high-skilled workers migrate, while low-skilled workers with low fertility preference $\underline{\beta}$ are indifferent between migrating and staying, and low-skilled workers with high fertility preference $\bar{\beta}$ always stay. There is another fertility-based SME with $\Gamma_H = 0$ and $0 < \Gamma_L < 1$: in this case, all agents with high fertility preference (type-$\bar{\beta}$) stay in rural areas, while low-skilled workers with preference $\underline{\beta}$ are indifferent between migrating and staying, and high-skilled workers with preference $\underline{\beta}$ always move. In a special case with $\Gamma_H = 1$ and $\Gamma_L = 0$, we have a pure skilled-based SME with all high-skilled workers migrating to cities and all low-skilled workers remaining as farmers. In another polar case with $\Gamma_H = 0$ and $\Gamma_L = 1$, we have a pure fertility-based SME with all workers with preference $\underline{\beta}$ migrating to cities and all with preference $\bar{\beta}$ remaining as farmers. Different types of SMEs are readily summarized below:

	Γ_H	Γ_L
Pure skill-based SME	1	0
Skill-based SME	1	$\in (0,1)$
Fertility-based SME	0	$\in (0,1)$
Pure fertility-based SME	0	1

We regard the last case as theoretically possible but not realistically likely – given that the typical observation is that cities are more attractive to high-skilled workers than farmland. For the sake of brevity, we will thus leave it out from our theoretical analysis.

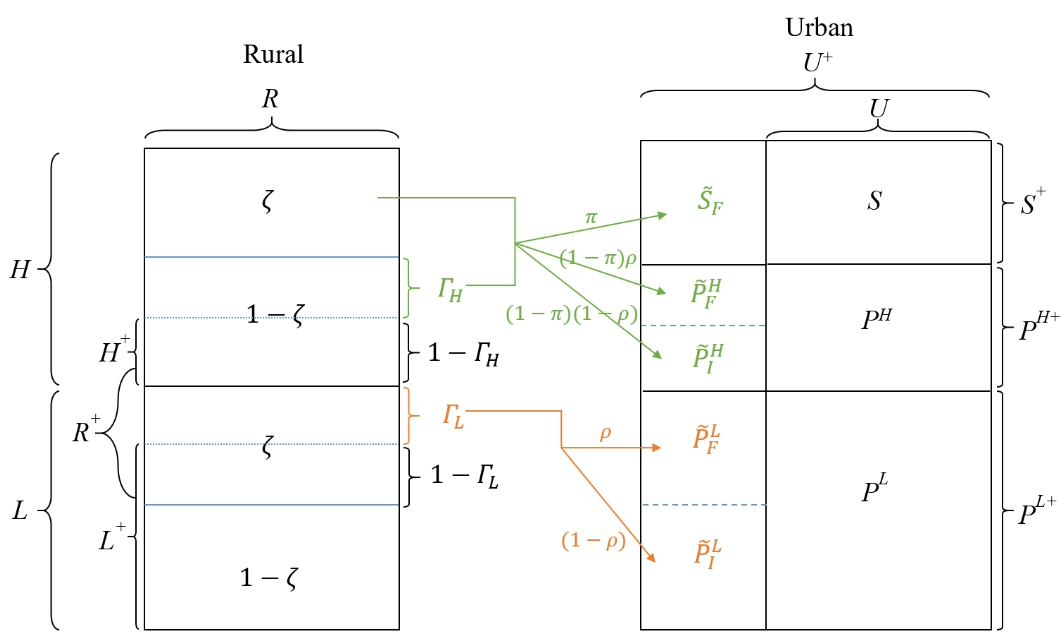
3.2 Evolution of Workers

As mentioned at the beginning of Section 2, agents are one-period lived and make migration decisions within the period, and hence the beginning-of-the-period population and the actual-working population stocks are different, with the differences resulting from the inflows of workers. Because children inherit their parents' status of residency, if rural migrant workers do not successfully obtain urban residency before exiting the market, in the next period their children will start life from rural areas with rural residency. Similarly, if a worker starts her life in urban areas, she holds urban residency bequeathed by her parents.

Denote U as the beginning-of-the-period workers with urban residency, whereas P^H and P^Las the beginning-of-the-period private sector high- and low-skilled workers, respectively. Denote $\tilde{S}_F$, $\tilde{P}_F^H$ and $\tilde{P}_F^L$ as the new migrants who successfully obtain urban residency, working as public sector, private sector high- and low-skilled workers, respectively. Denote $\tilde{P}_I^H$ and $\tilde{P}_I^L$ as the new comers working as private sector high- and low-skilled workers but failing to obtain urban residency. Denote H and L as the beginning-of-the-period rural high- and rural low-skilled workers. The detailed notations of population flows are summarized in Table 1. Figure 4 provides the population flows chart in the model.

[Insert Table 1 about here]

Figure 4: Population Flow Chart



The beginning-of-the-period population identity equations in urban and rural areas are:[3]

$$U = S + P^H + P^L, \tag{23}$$

$$R = H + L. \tag{24}$$

The actual-working populations in urban areas under the equilibrium we examine are:

$$S^+ = S + \tilde{S}_F = S + \underbrace{[\zeta + (1-\zeta)\,\Gamma_H]\,\pi H}_{\text{obtain urban residency immediately upon arrival}}, \tag{25}$$

[3]For urban workers who do not have urban residency, their children will hold rural residency at birth and start their life in rural areas. As a result, we have $P_I^H = P_I^L = 0$.

$$
\begin{aligned}
P^{H+} &= P^H + \tilde{P}_F^H + \tilde{P}_I^H \\
&= P^H + \underbrace{[\zeta + (1-\zeta)\,\Gamma_H]\,(1-\pi)\,\rho H}_{\text{obtain urban residency}} + \underbrace{[\zeta + (1-\zeta)\,\Gamma_H]\,(1-\pi)\,(1-\rho)\,H}_{\text{still hold rural residency}} \\
&= P^H + [\zeta + (1-\zeta)\,\Gamma_H]\,(1-\pi)\,H,
\end{aligned} \tag{26}
$$

$$
\begin{aligned}
P^{L+} &= P^L + \tilde{P}_F^L + \tilde{P}_I^L \\
&= P^L + \underbrace{\zeta\Gamma_L\rho L}_{\text{obtain urban residency}} + \underbrace{\zeta\Gamma_L\,(1-\rho)\,L}_{\text{still hold rural residency}} \\
&= P^L + \zeta\Gamma_L L,
\end{aligned} \tag{27}
$$

where $\tilde{Z}$ denotes the inflow of Z within the period. Total number of agents working in urban areas after migration inflows is thus equal to:

$$
\begin{aligned}
U^+ &= S^+ + P^{H+} + P^{L+} \\
&= S + P^H + P^L + [\zeta + (1-\zeta)\,\Gamma_H]\,H + \zeta\Gamma_L L \\
&= U + [\zeta + (1-\zeta)\,\Gamma_H]\,H + \zeta\Gamma_L L.
\end{aligned} \tag{28}
$$

In a similar manner, we write down the actual-working populations in rural areas after migration outflows as:

$$
R^+ = H^+ + L^+ = (1-\zeta)\,(1-\Gamma_H)\,H + (1-\zeta\Gamma_L)\,L. \tag{29}
$$

As children inherit the skill levels (i.e., jobs) and residency status directly from parents and all agents live for one period, the evolutions of workers in the public and the private sectors are:

$$
S' = \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\,n_F^*|_{\bar{\beta}}\right] S + \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\,\Gamma_H n_F^*|_{\bar{\beta}}\right] \pi H, \tag{30}
$$

$$
P^{H'} = \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\,n_F^*|_{\bar{\beta}}\right] P_F^H + \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\,\Gamma_H n_F^*|_{\bar{\beta}}\right] (1-\pi)\,\rho H, \tag{31}
$$

$$
P^{L'} = \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\,n_F^*|_{\bar{\beta}}\right] P_F^L + \zeta\Gamma_L n_F^*|_{\underline{\beta}}\rho L, \tag{32}
$$

where Z' denotes the next period value of Z. The evolution equation for U can be written accordingly follows:

$$
U' = S' + P^{H'} + P^{L'}. \tag{33}
$$

The evolution equations for rural high- and low-skilled workers and total rural workers with rural residency can be written accordingly:

$$
H' = H\left\{(1-\rho)\,(1-\pi)\left[\zeta n_I^*|_{\underline{\beta}} + (1-\zeta)\,\Gamma_H n_I^*|_{\bar{\beta}}\right] + (1-\zeta)\,(1-\Gamma_H)\,n_R^*|_{\bar{\beta}}\right\}, \tag{34}
$$

$$
L' = L\left\{(1-\rho)\,\zeta\Gamma_L n_I^*|_{\underline{\beta}} + \zeta\,(1-\Gamma_L)\,n_R^*|_{\underline{\beta}} + (1-\zeta)\,n_R^*|_{\bar{\beta}}\right\}, \tag{35}
$$

$$
R' = H' + L'. \tag{36}
$$

3.3 Urban Benefits

Urban benefits, inclusive of urban amenities, such as parks, schools, museums, libraries, medical services, childcare and old age allowances, and other public services, are assumed to be financed by urban embarked taxes. Total urban taxes collected by the government are:

$$\begin{aligned} T &= \left\{S + P_F^H + P_F^L + [\zeta + (1-\zeta)\,\Gamma_H]\,\pi H\right\}\tau \\ &\quad + \{[\zeta + (1-\zeta)\,\Gamma_H]\,(1-\pi)\,\rho H + \zeta\Gamma_L\rho L\}\,\mu\tau. \end{aligned} \tag{37}$$

We assume that the government provides the urban benefits B to all residents with urban status based on an even distribution rule:

$$B = B_0 G, \tag{38}$$

where G is the per capita budget for amenities and benefits, and B_0 is the government's technology scaling factor in the provision of urban amenities and benefits. Assume that the government runs a balanced budget in every period. Then periodic balanced government budget implies:

$$G = \frac{T}{U + \tilde{S}_F + \tilde{P}_F^H + \tilde{P}_F^L}.$$

3.4 Migration Equilibrium

In equilibrium, all urban labor markets clear under the factor prices $\left\{w_S, w_P^H, w_P^L\right\}$ given by (5), (6) and (7):

$$S^d = S^+,\ P^{H,d} = P^{H+},\ P^{L,d} = P^{L+}, \tag{39}$$

where S^d, $P^{H,d}$ and $P^{L,d}$ are the labor demands in specific sectors. Finally, rural labor market clears under the rural farming income given by (2):

$$R^d = R^+. \tag{40}$$

where R^d is the demand for rural labor.

We define the competitive equilibrium of the model below.

Definition. *A **dynamic competitive migration equilibrium** (DCME) of the model consists of migration decisions, rural farming income x, and urban wage rates $\left\{w_S, w_P^H, w_P^L\right\}$, such that*

(i) *(Optimization) given rural farming income x and urban wage rates $\left\{w_S, w_P^H, w_P^L\right\}$, based on their residency status, agents choose numbers of children according to (17) and (19); furthermore, rural high- and low-skilled agents make migration decisions according to (22);*

(ii) *(Market clearing) rural farming income satisfies (2), urban wage rates $\left\{w_S, w_P^H, w_P^L\right\}$ satisfy (5), (6) and (7), and labor markets clear according to (39) and (40);*

(iii) *(Urban amenities) the amenities in urban areas are supplied according to (38);*

(iv) *(Workers laws of motion) given the initial population* $\{H^0, L^0, S^0, P^{H,0}, P^{L,0}\}$*, high- and low-skilled workers in rural, urban public and urban private sectors evolve according to (30)-(36), with workers actually devoted to production given by (25)-(29).*

We next define the balanced-growth equilibrium for the rest of our analysis.

Definition. *A **balanced-growth migration equilibrium (BGME)** of the model is a DCME where the growth rate of population variables are constant as follows:*

$$\frac{Z'}{Z} = constant,$$

where $Z = S, R, P^H$ *and* P^L*.*

Along a balanced growth path, from (30)-(32), we get:

$$\frac{S'}{S} = \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\, n_F^*|_{\bar{\beta}}\right] + \left[\zeta\pi n_F^*|_{\underline{\beta}} + (1-\zeta)\,\pi\Gamma_H n_F^*|_{\bar{\beta}}\right]\frac{H}{S}, \tag{41}$$

$$\frac{P^{H\prime}}{P^H} = \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\, n_F^*|_{\bar{\beta}}\right] + \left[\rho\zeta\,(1-\pi)\, n_F^*|_{\underline{\beta}} + \rho\,(1-\zeta)\,(1-\pi)\,\Gamma_H n_F^*|_{\bar{\beta}}\right]\frac{H}{P^H}, \tag{42}$$

$$\frac{P^{L\prime}}{P^L} = \left[\zeta n_F^*|_{\underline{\beta}} + (1-\zeta)\, n_F^*|_{\bar{\beta}}\right] + \left(\rho\zeta\Gamma_L n_F^*|_{\underline{\beta}}\right)\frac{L}{P^L}. \tag{43}$$

Thus, along a balanced growth path, we have a constant ratio of public sector workers to high-skilled workers (S/H) as well as constant ratios for workers of different skill types in urban private sector (P^H/H and P^L/L). Next, from (34)-(35), we have constant growth rates of different skill-type workers. These together with the fact that the growth rate of R is constant, we get a constant ratio of high-skilled to low-skilled workers (H/L) from (36). This in turn implies that the ratio of high-skilled to low-skilled workers in the urban private sector is constant (P^H/P^L). Finally, from (23), we can show that the growth rate of U, as well as its ratio to high-skilled workers are constant.

We are now ready to establish the property of common growth and, most importantly, the existence the properties of a mixed migration equilibrium.

Proposition 4. (Common Growth) *At the BGME, the model exhibits common growth rate property:*

$$\frac{Z'}{Z} = g,$$

where $Z = S, U, R, H, L, P^H$ *and* P^L*.*

We now present the first main finding that concerns the existence of a MME.

Theorem 1. (Mixed Migration Equilibrium) *Under proper ranges of migration costs and urban-rural income differentials, a mixed migration equilibrium arises along a balanced growth path. Moreover, a better urban amenity, a larger childrearing subsidy, a lower urban-rural childrearing cost differential, a lower urban fertility penalty, or a weakened rural land entitlement tends to result in a higher fraction of type-*$\{H, \bar{\beta}\}$ *and type-*$\{L, \underline{\beta}\}$ *agents choosing to migrate from rural to urban.*

While the formal proof is relegated to Appendix A.1, Theorem 1 is established by means of proof by construction. To do so, we define a general class of indifference boundaries for the high-skilled and low-skilled agents with type-β facing a migration cost ψ:

$$\begin{aligned} \Delta V_H(\beta,\psi) &\equiv \pi V^S(\beta) + (1-\pi) V^{P,H}(\beta) - \psi - V^R(\beta) = 0 \\ \Delta V_L(\beta,\psi) &\equiv V^{P,L}(\beta) - \psi - V^R(\beta) = 0 \end{aligned}$$

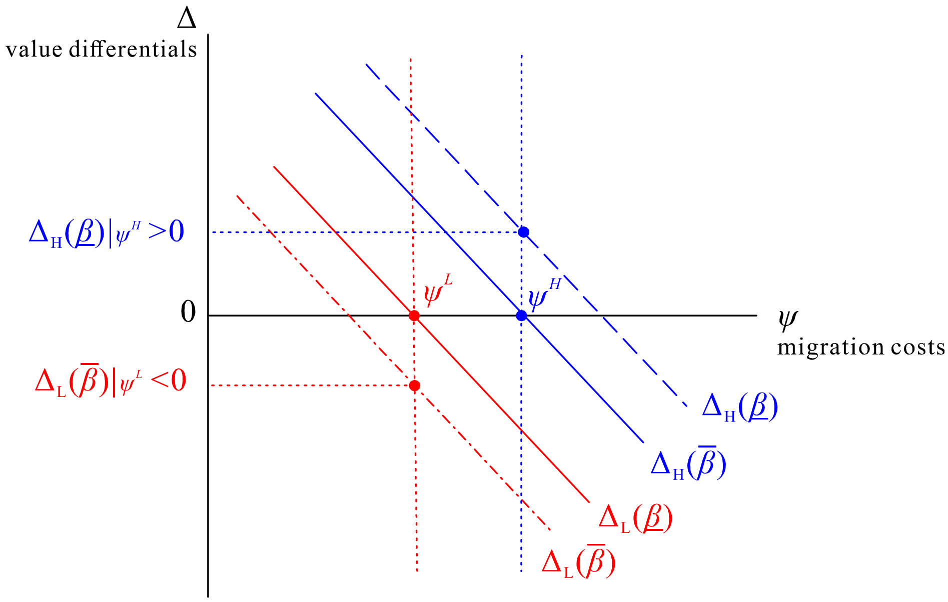
which are both linear and decreasing in the migration cost of migration. To begin, we use (20) and (21) to identify conditions under which type-$\{H, \underline{\beta}\}$ workers always choose to migrate to cities whereas type-$\{L, \bar{\beta}\}$ always decide to stay in rural areas, i.e., $\Delta V_H\left(\underline{\beta}, \psi^H\right) > 0 > \Delta V_L\left(\bar{\beta}, \psi^L\right)$. This task is trivial because, for any fertility preference pair $\left\{\underline{\beta}, \bar{\beta}\right\}$, we can always adjust the migration costs of migration $\left\{\psi^L, \psi^H\right\}$ for the two inequalities to hold. Basically this requires that ψ^L is sufficiently high but ψ^H sufficiently low.

The major task is therefore to check the indifference boundaries of type-$\{H, \bar{\beta}\}$ and type-$\{L, \underline{\beta}\}$ agents that may lead to interior solution so that $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0 = \Delta V_L\left(\underline{\beta}, \psi^L\right)$. To do so, we first write all the costs (migration, childrearing and penalties or subsidies) in proportion to wage incomes. Then it is convenient to define urban-rural income differentials measured by the ratios of urban net wage to farmer's income:

$$\varsigma_H(\beta) \equiv \frac{\tilde{w}_P^H(\beta)}{x}, \quad \varsigma_S(\beta) \equiv \frac{\tilde{w}_S(\beta)}{x}, \quad \varsigma_L(\beta) \equiv \frac{\tilde{w}_P^L(\beta)}{x}$$

Straightforward examination of the value functions suggest that an increase in $\varsigma_H(\beta)$ or $\varsigma_S(\beta)$ tends to shift up the high-skilled indifference boundary $\Delta V_H\left(\beta, \psi^H\right) = 0$, whereas an increase in $\varsigma_L(\beta)$ tends to shift up the low-skilled indifference boundary $\Delta V_L\left(\beta, \psi^L\right) = 0$. Thus, with proper urban-rural income differentials, we can assure $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0 = \Delta V_L\left(\underline{\beta}, \psi^L\right)$ under which a fraction of both high-skilled and low-skilled workers $(\Gamma_H, \Gamma_L) \in (0,1) \times (0,1)$ migrate to cities. This proof by construction is illustrated by Figure 5, given $\psi^L < \psi^H$ (which is for illustrative purposes but inessential for the proof). What is important is that the parametric space supporting a mixed migration equilibrium is dense and hence nonempty. By similar arguments, we can perform comparative static analysis to establish that urban amenities and childrearing subsidies serve as positive forces for migration (shifting up indifference boundaries), whereas childrearing cost differentials, fertility penalties and rural land entitlement requirements as negative forces (shifting down indifference boundaries).

Figure 5: Indifference Boundaries in MME



From the indifference boundaries, we get a novel locational quantity-quality tradeoff for rural-urban migration, reflected by the presence of an expected locational quality gain and an expected fertility loss upon migrating to cities:

$$\Delta V_H(\beta,\psi) = \underbrace{\begin{array}{c}(1-\theta)\,\theta\left\{\pi w_S + (1-\pi)\,w_P^H - [\pi + (1-\pi)\,\rho\mu]\,\tau - x\right\} \\ + [\pi + (1-\pi)\,\rho\mu]\,B - \psi\end{array}}_{\text{expected locational quality gain (+)}} \underbrace{+(1-\varepsilon)\,\beta\left\{\begin{array}{c}\pi\,(n_F^*|_\beta)^\varepsilon - (n_R^*|_\beta)^\varepsilon \\ +(1-\pi)\left[\rho\,(n_F^*|_\beta)^\varepsilon + (1-\rho)\,(n_I^*|_\beta)^\varepsilon\right]\end{array}\right\}}_{\text{expected fertility loss (-)}},$$

and

$$\Delta V_L(\beta,\psi) = \underbrace{(1-\theta)\,\theta\left[\rho\left(w_P^L - \mu\tau\right) + (1-\rho)w_P^L - x\right] + \rho\mu B - \psi}_{\text{expected locational quality gain (+)}} + \underbrace{(1-\varepsilon)\,\beta\left[\rho\,(n_F^*|_\beta)^\varepsilon + (1-\rho)\,(n_I^*|_\beta)^\varepsilon - (n_R^*|_\beta)^\varepsilon\right]}_{\text{expected fertility loss (-)}}.$$

Again, the formal proof is relegated to Appendix A.2, but this property is readily summarized in the following.

Theorem 2. (Locational quantity-quality tradeoff) *At the BGME, the rural-to-urban migration decision features a locational quantity-quality tradeoff between payoffs from locational quality and fertility.*

The intuition underlying Theorem 2 is not difficult to get. Urban provides better job opportunities and amenities but has higher childrearing costs, an urban migrant tends to reduce the number of children but instead invest more in the quality of children, bring their children to better careers and amenities.

Just how important this locational quantity-quality trade-off in Theorem 2 is and whether the conditions required in Theorem 1 are met are, nonetheless, quantitative questions to which we now turn.

4 Quantitative Analysis

In this section, we quantify our theoretical model, taking China as an example. It is an interesting case to study due to China's tight migration regulation and population control in the past decades. These policies, the *hukou* regulation system, the reallocation of land entitlement and the one-child policy, not only provide costs and benefits to decision-making but also interconnect to each other to jointly shape individual's choices on fertility and rural-urban migration. Our task is thus to investigate and quantify how these policies influence the macroeconomic performance in China.

Below we first provide a brief overview of the three policies, while relegating the details to Appendix B. We then calibrate our model to fit the data from China during 1980-2007. Based on the calibrated benchmark economy, various counterfactual policy experiments are conducted to study their consequences for fertility decisions, patterns of rural-urban migration and economic development in China.

4.1 Institutional Background

China's migration control is based on the household registration system, *hukou*, implemented since 1950. Under the *hukou* regulation, permission is required for formal rural-urban migration and annual quotas on migrants are controlled by the government. Therefore, labor markets become locationally segmented. In addition, in cities, most social services are granted with urban *hukou*. However, migrants may not automatically obtain urban *hukou*. While those joining the public sector (via the channel of *zhaogong* and *zhaogan*) obtain urban *hukou* immediately, some private-sector migrants move without urban residency (temporary migrants) or will be granted with urban *hukou* at a later date. Notably, there is another channel via attending college education (*zhaosheng*, as studied in Liao, Wang, Wang and Yip 2017), which is not the focus of this paper.

A migration-related policy is the reallocation of land entitlement. In rural areas, people are bound to land and the distribution of land use rights is mainly based on the household size. Land, however, is officially owned by village collectives (communal land). Since people do not have the property right of land, land cannot be sold by those moving to urban and become idle land. After several years, village collectives have the right to reallocate the use rights of land according to changes in the household size. As a result, those moving to urban areas face a risk at losing their land entitlement. Even with land tenure security reform that formally set the duration of land contract at 30 years and land transfers are allowed, the transfer contracts are still largely informal and the problem of land expropriation remains – the problem is indeed exacerbated due to urban expansion and infrastructure development.

China's well-known one-child policy also interplays with the *hukou* system and affects migration decisions. As the one-child policy was implemented by local governments, the population control turns out to be differential across locations and sectors. For example, in rural areas, the penalties on above-quota births could be about 10-20 percent of family income lasting for 3-14 years. Those working in the public sector may lose the eligibility for promotion, be demoted or be forced to quit their jobs. Rural-urban migrants who are granted with urban *hukou* follow the fertility restrictions of their destinations, while temporary migrants are regulated by the rules of their original places. As a result, those with high fertility preference may have lower incentive to migrate from rural to urban areas and become more reluctant to work in the public sector. This subsequently creates an interactive channel through which migration and fertility decisions are interconnected – the channel we explore in this paper.

4.2 Calibration

The period under examination is 1980-2007. That is, we focus on the period after China' economic reform in 1980 but before the financial tsunami. The majority of rural workers migrate to cities at young ages. To calibrate the theoretical model, we assume that agents enter the economy at age 18, remain economically active for 36 years, and exit the economy (or retire) at age 54.[4] Thus, the model period in the calibration is set at 36 years. We categorize those with senior high school degree or above as high-skilled workers, and others as low-skilled workers. Besides, to better capture various above-quota penalties implemented by local governments, we assume low-skilled workers bear the basic locational above-quota fines ($\bar{\phi}_U$ and $\bar{\phi}_R$), while high-skilled workers in different sectors and locations bear the extra above-quota fines ($\bar{\phi}_H$, $\bar{\phi}_S$ and $\bar{\phi}_P^H$). The details of above-quota penalties will be discussed later. In what follows, we first summarize the parameters and variables that we are going to calibrate and solve. Second, we describe the population ratios that are required for calibration. Third, we discuss the procedure of determining the parameters and variables, either by calibration or taken directly from the literature or data. Detailed information on data sources and the methods we imputed our targets are relegated to Appendix C.

There are 31 parameters and variables to be calibrated and determined, including (i) preference parameters: the altruistic factor of savings in offspring θ, preference toward children $\underline{\beta}$ and $\bar{\beta}$, the utility concavity in the quantity of children ε, and the migration costs for high- and low-skilled workers, ψ^H and ψ^L; (ii) the proportion of agents enjoying less from having children, ζ; (iii) childrearing costs, above-quota penalties and fertility constraint parameters: ϕ_U^0, ϕ_R^0, $\bar{\phi}_U$, $\bar{\phi}_R$, $\bar{\phi}_H$, $\bar{\phi}_S$, $\bar{\phi}_P^H$, $\bar{n}_U$ and $\bar{n}_R$; (iv) parameters related to urban benefits and urban embarked tax: μ, B_0 and τ; (v) production technology parameters: A_S, A_P, α, σ, η, z, δ, and q; (vi) probabilities of obtaining urban *hukou* and position in public sector, ρ and π; and (vii) fractions of type-$\{H, \bar{\beta}\}$ and type-$\{L, \underline{\beta}\}$ workers migrating to urban areas, Γ_H and Γ_L.

[4] China is one of the countries that workers retire at early age. See Appendix C for more discussion on the pattern of early retirement in China.

There are two groups of population ratios that we need for calibration, including the begining-of-the-period population ($\frac{U}{R}$, $\frac{H}{L}$, $\frac{S}{P}$, $\frac{S}{U}$ and $\frac{P^H}{P^L}$) and workers that actually work within the period ($\frac{U}{U^+}$, $\frac{P^{H+}}{P^{L+}}$, $\frac{S^+}{P^{H+}}$ and $\frac{R^+}{R}$). We compute the ratio of $\frac{U}{R}$ using population data by urban and rural residence, and obtain an average of 0.4579 during 1980-2007. To compute the ratio of $\frac{H}{L}$, we need information on rural workers' education level. As the data became available since 1985, we back out the ratios in 1980-1984 using the growth rate of the $\frac{H}{L}$ ratios from 1985 to 2007. The average of the $\frac{H}{L}$ ratios is 0.1076 during 1980-2007. The $\frac{S}{P}$ and $\frac{S}{U}$ ratios are calculated using the data from *China Statistical Yearbook*. We define employees in state-owned units to be workers in public sector and employees in other units in cities and towns as urban private sectors. The average of the $\frac{S}{P}$ ratio during 1980-2007 is 1.5235 and $\frac{S}{U}$ is 0.6094. The last begining-of-the-period population ratio we need is the $\frac{P^H}{P^L}$ ratio. To compute this ratio, we need workers' information on two dimensions: employed sectors and education levels. As the suitable data is not abundant, we resort to the Urban Household Survey (UHS). We first distinguish private workers from those working in public sector. Second, those who have already retired but re-entered the workforce are excluded. Then, using our definition of high-skilled workers, we obtain a series of the $\frac{P^H}{P^L}$ ratios during 1987-2007. Third, we back out the $\frac{P^H}{P^L}$ ratios for 1980-1986 based on the geometric growth rate of the $\frac{P^H}{P^L}$ ratios over the period of 1987-2007. The average ratio of $\frac{P^H}{P^L}$ during 1980-2007 is 0.8159.

The second group of population ratios is workers that actually work within the period. The first ratio that we need is $\frac{U}{U^+}$. Urban population (U) is directly obtained from *China Population and Employment Statistics Yearbook* 2010. The difference between U and U^+ is the rural-urban floating population. As the term "*mangliu*", or the so-called "blind flow", refers to massive migrants fluxing from rural areas to cities, rural-urban migrants in fact are the majority of China's internal migration. It is thus reasonable to assume that the entire floating population in data is rural-urban migrants. The floating population data is taken from Department of Population and Employment Statistics, National Bureau of Statistics of China. Using the data, we first compute the ratios of floating to urban population. For those years without data, intrapolation is implemented. Then, the ratios of floating to urban population are converted to the ratios of $\frac{U}{U^+}$ and the average of $\frac{U}{U^+}$ during 1980-2007 is 0.8764. To compute the workers that actually work in each sector, we need to know the sectors that floating population actually work in. However, the information is very limited, especially for early years. According to the Rural-Urban Migrant Survey (RUMS), the proportion of migrant workers employed as production workers, service workers, private enterprise owners, or self-employed reached 93 percent in 2007, while 81 percent of them were employed in private enterprises or self-employed. Based on this information, we can infer that roughly 7 percent of migrants worked in the public sector in 2007, while at most 12 percent of migrants were private business owners. As it was relatively inflexible for the public sector to hire migrants in early years and our data period spans from 1980 to 2007, it is natural to see the 7 percent of migrants working in the public sector as an upper bound. We thus choose to set 5 percent of the entire floating population ending up with jobs in public sector, while 20 percent and 75 percent of the floating population employed as high- and low-skilled workers at private sectors, respectively. With this assumption, the begining-of-the-period population ratios and the population identity equations, we are able to compute the ratios of $\frac{P^{H+}}{P^{L+}}$, $\frac{S^+}{P^{H+}}$, and $\frac{R^+}{R}$. The average of $\frac{P^{H+}}{P^{L+}}$ during 1980-2007 is

0.6348, the average of $\frac{S+}{P^{H+}}$ becomes 3.0262, and the average of $\frac{R^+}{R}$ is 0.9354.[5]

Now, we are ready to calibrate the model to data from China. The rural per capita income y_R, which is simply equal to x in equation (2), is normalized to one during 1980-2007. In rural China, land use rights are distributed based on family size and reallocated in every 5-10 years. Hence the average duration for land reallocation is 7.5 years. Adjusted by the model period, we obtain $\delta = 0.2083$. *China Statistical Yearbook* reports the average rural land per person. Thus $q = 2.3315$ (mou) during the period of 1980-2007. Then, the farming technology z can be computed from equation (2) and equal to 0.4067.

To pin down the parameters in urban production sectors, we need three income ratios from data, $\frac{w_S}{w_P^H}$, $\frac{w_P^H}{w_P^L}$ (skill premium) and $\frac{y_U}{y_R}$ (urban premium).[6] We use the data in UHS to calculate the first two wage ratios and the data from *China Statistical Yearbook* to compute urban premium. For the years without data, intrapolation is implemented to impute the corresponding values. Thus, we obtain $\frac{w_P^H}{w_P^L} = 1.3944$, $\frac{w_S}{w_P^H} = 0.8814$, and $\frac{y_U}{y_R} = 1.9641$ for the averages of 1980-2007. We set $\sigma = 0.8333$, which corresponds to an elasticity of substitution (EIS) between high- and low-skilled workers to be 6. This value of the EIS between high- and low-skilled workers falls within the range of the EIS estimates for East Asian countries.[7] By setting the CES production share of high-skilled workers α at 0.5, η is calibrated to match the skill premium, $\frac{w_P^H}{w_P^L}$, and is equal to 1.3608. The technological scaling factors of public sector and private firms, A_S and A_P, are jointly calibrated by matching the urban premium $\frac{y_U}{y_R}$ and $\frac{w_S}{w_P^H}$. A_S and A_P are equal to 2.0214 and 3.3287, respectively.

Next, we turn to decide the four proportions or probabilities, ζ, π, Γ_H and Γ_L. First, we compute ζ based on the survey data of family size preference by categorizing agents preferring less than or equal to one child as $\underline{\beta}$-type agents, and those desiring more than one child as $\bar{\beta}$-type agents. We obtain $\zeta = 0.15$.[8] The rest three probabilities or proportions of migration (π, Γ_H and Γ_L) are jointly calibrated to match the ratios of $\frac{P^{H+}}{P^{L+}}$, $\frac{S^+}{P^{H+}}$, and $1 - \frac{U}{U^+}$ over 1980-2007. The calibrated values for π, Γ_H and Γ_L are 0.2, 0.019 and 0.3576, respectively. The implied fraction of high-skilled movers is 16.6 percent, three times as high as that of low-skilled movers (5.36 percent). Thus, skill sorting in our calibrated MME is consistent with Gollin, Lagakos, and Waugh (2014) who find robustly urban workers to have higher skills measured by years of schooling using data from 151 countries.

[5] In Appendix D, sensitivity tests using different but reasonable assumptions on the fraction of floating populations in different sectors are performed. By recalibrating the model and re-conducting all the policy experiments which will be elaborated below, we find that all policy experiments results on urbanization rates, fertility responses, skill premium and urban premium are very robust.

[6] Urban per capita income y_U is defined as the average output per worker in urban areas, i.e., $y_U = \frac{Y_S+Y_P}{U^+}$, while rural per capita income is simply $y_R = x = 1$.

[7] In the literature, the estimates for developed countries range from 1 to 3 (see, for example, Autor, Katz and Krueger 1998;, Acemoglu 2003; and Ciccone and Peri 2005), while the estimated values for Asian economies are larger, mostly falling between 2 and 7. For example, Toh and Tat (2012) estimated that the value for Singapore is 4.249. Te Velde and Morrissey (2004) used data from Singapore, Hong Kong, Korea, the Philippines and Thailand and obtained a value of 2.78. The results in Gindling and Sun (2002) imply that the value in Taiwan is between 2.3 and 7.4.

[8] See Appendix C for the detailed description on the survey data of family size preference.

Regarding the parameters for the institution of the *hukou* system, μ and ρ, we determine their values from the literature. Prior to 1994, it was very difficult for rural migrants to obtain urban *hukou*. After 1994, rural migrants can get urban hukou, usually at a range of time for two to five years, via the blue-stamp system. We thus assume that $\mu = 0$ prior to 1994 and $\mu = \frac{2+5}{2} = 3.5$ years for a migrant to obtain urban residency and hence to be qualified for urban benefits. Therefore, the average μ, the fraction of lifetime that a migrant worker successfully obtained urban residency to enjoy urban benefits, is $1 - \frac{0+3.5}{2}/36 = 0.4514$ for the period of 1980 to 2007.[9] As for ρ, based on field interviews, only about 11 percent of the interviews from rural areas successfully obtained urban residency, so we set ρ at 0.11.[10]

We now turn to determine the fertility constraints in rural and urban areas, $\bar{n}_U$ and $\bar{n}_R$, and the basic above-quota fines, $\bar{\phi}_R$ and $\bar{\phi}_U$. According to Ebenstein (2010), the average fertility quota per couple in urban and in rural China were one child and 1.6 children, respectively. Since our theoretical framework is a unisex model, to link the data to our model, we follow the standard method in the endogenous fertility literature to divide the fertility quota per family by two. We thus set $\bar{n}_U$ and $\bar{n}_R$ to 0.5 and 0.8, respectively. The implementation of the one-child policy varied across regions and sectors. The above-quota penalty could be not only in the form of monetary fines, but also in non-monetary forms. For example, workers in the public sector could lose jobs if violating the fertility policy. As there is no perfect method to impute the total above-quota penalties paid by parents, we assume that low-skilled workers bear the basic above-quota fines, $\bar{\phi}_R$ for rural low-skilled workers and $\bar{\phi}_U$ for urban low-skilled workers. High-skilled workers bear extra sector-specific fines (on top of the basic fines), which are $\bar{\phi}_H$, $\bar{\phi}_S$ and $\bar{\phi}_P^H$ for rural high-skilled workers, urban employees in public sector and urban high-skilled worker in private sector, respectively. The three extra fines born by high-skilled workers are discussed in the next paragraph. Here we focus on the determination of the basic above-quota fines. Denote $\tilde{\phi}_R$ as the proportion of the basic above-quota fine to a rural agent's wage and $\tilde{\phi}_U$ is the proportion to an urban agent's wage. Using the penalty data provided by Ebenstein (2010), we obtain $\tilde{\phi}_R$ =1.5928 and $\tilde{\phi}_U$ =1.6654.[11]

The determinations of the two childrearing costs (ϕ_U^0 and ϕ_R^0) and the three extra above-quota fines born by high-skilled workers ($\bar{\phi}_H$, $\bar{\phi}_S$, and $\bar{\phi}_P^H$) are summarized as follows. First, similar to the basic above-quota fines, we define $\tilde{\phi}_U^0$, $\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$ as the proportions of childrearing cost (or extra fine) to an agent's wage. Second, we set $\tilde{\phi}_U^0$ at 25 percent of an urban agent's income as it is a common value in urban China.[12] Third, the rest four parameters ($\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$) are calibrated by matching four fertility targets n_R^L, n_R^H, n_S and n_P^H.[13] Thus, we have $\tilde{\phi}_R^0$=0.4386,

[9] The period we examine is 1980-2007, and 1980-1994 roughly amounts to half of the examined period.

[10] See Appendix C for more information on the determination for μ and ρ.

[11] In other words, the rate of total above-quota fine paid by rural low-skilled worker is $\tilde{\phi}_R$; the rate of total fine paid by rural high-skilled worker is $\tilde{\phi}_R + \tilde{\phi}_H$; an urban low-skilled worker pays the rate $\tilde{\phi}_U$; a worker in public sector bears the rate $\tilde{\phi}_U + \tilde{\phi}_S$; and an urban high-skilled worker in private sector bears the rate $\tilde{\phi}_U + \tilde{\phi}_P^H$.

[12] See Appendix C for more literature discussion on urban child rearing cost.

[13] The method we impute the fertility targets and the data sources are relegated to Appendix C. In the calibration, for example, we compute a weighted fertility of P^H and $\tilde{P}_F^H$ to match n_P^H. Fertility in other sectors are conducted accordingly. Besides, as our model is unisex, we match a half of the imputed fertility in the calibration.

$\tilde{\phi}_H$=5.3123, $\tilde{\phi}_S$=2.1439 and $\tilde{\phi}_P^H$=0.2382.

There are four preference parameters left (ε, θ, $\underline{\beta}$ and $\bar{\beta}$). The concavity in the utility function for the number of children ε is set at 0.1, which is roughly equal to the value used in Gobbi (2013). For the altruistic factor θ, the Leontief preference implies that $c = \frac{(1-\theta)nb}{\theta}$, and hence $\frac{c}{nb} = \frac{1-\theta}{\theta}$. Therefore, $1 - \theta$ represents the fraction of income being spent on own consumption and θ is the fraction of income for saving. With the information on rural per capita income and consumption reported in *China Statistical Yearbook*, we compute a time series of θ and the average of θ becomes 0.2124 during 1980-2007. We thus set θ at 0.21. Preference parameters are not observable, so we simply set $\underline{\beta}$ at 0.1. The last preference parameter, $\bar{\beta}$, is jointly calibrated with the aforementioned rural childrearing cost and the three extra fines ($\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$). In addition to the four data moments of fertility we described above, we also match n_P^L in the joint calibration. The calibrated $\bar{\beta}$ is 0.5346.

We are left with the calibration for the urban embarked tax τ, urban benefits B, the government's technology scaling factor in the provision of urban benefits B_0 and the migration costs of rural type-$\{H, \bar{\beta}\}$ and type-$\{L, \underline{\beta}\}$ agents, ψ^H and ψ^L. There is no perfect measure to proxy urban benefits. As urban workers usually enjoy government provided pension benefits, we thus use urban pension benefits to proxy B. To compute B, we use the pension replacement rate in China. It is multiplied by the urban average income during the examined period and adjusted by the model period as well as the average years that an urban worker enjoys after retirement. Thus, B is 0.9803. Following Song, Storesletten, Wang and Zilibotti (2015), the urban social security tax τ is set at 20% of an urban agent's income. The total social security taxes are collected to finance urban benefits. With the technology that the government provides urban benefits, we are able to determine B_0, which is 2.4863. Finally, ψ^H and ψ^L are calibrated using the indifference equations for migration, (20) and (21), and are equal to 0.4230 and 0.1539, respectively. This result indicates that high-skilled workers who enjoy more from having children suffer more from migrating to cities. The calibration result is summarized in Table 2.

[Insert Table 2 about here]

In Table 3, we further report important ratios implied by the calibration results. Our results indicate that private sector has much better technology than the public sector and the rural agricultural sector. Among high-skilled rural workers, more than 15 percent of them decide to migrate to cities, while about 95 percent of rural low-skilled workers choose to stay in countryside. Compared with rural workers, the child-rearing costs for workers in the public sector and private high-skilled workers are both higher. However, private low-skilled parents bear slightly lower child-rearing costs than rural workers. This could be due to the higher implicit cost in rural areas, such as living far away from schools or due to relatively higher child-rearing cost for rural high-skilled parents (an argument by Cheung, 2018, for examining demographic transition and structural transformation in the U.S. at the turn of the twentieth century). Regarding the above-quota penalty, workers in the public sector were penalized the most heavily, followed by rural high-skilled workers, while rural low-skilled workers were punished the least. The result is consistent with the reality. In fact, rural high-skilled workers are more likely to be leaders in the village, and tend to hold positions designated by the government. The result indicates that no matter the working location was, workers in the public sector were being seriously monitored by the government. Based on the calibrated parameters, we now proceed to policy experiments.

[Insert Table 3 about here]

4.3 Policy Experiments

Based on the benchmark model, we are now ready to conduct policy experiments. More specifically, we want to investigate how the three types of policies, including (i) the population control polices, (ii) the migration polices (or the *hukou* regulations), and (iii) the land entitlement reallocation policies, affect the joint decisions on rural-urban migration and fertility and the macroeconomic performance of China. In line with the discussion in Section 3.1, we restrict our attention to a benchmark economy with the most plausible migration pattern: Type-$\{H, \underline{\beta}\}$ workers always migrate to cities, type-$\{L, \bar{\beta}\}$ workers always stay in the rural, whereas type-$\{H, \bar{\beta}\}$ and type-$\{L, \underline{\beta}\}$ agents are indifferent between migrating and staying in rural areas. As some of our counterfactual experiments involve large changes in the institutions that workers face, we may end up with corner solutions ($\Gamma_H = \Gamma_L = 0$), or SMEs with pure skill-based or skill-based migration ($\Gamma_H = 1, \Gamma_L \in [0, 1)$) or pure fertility-based or fertility-based migration ($\Gamma_H = 0, \Gamma_L \in (0, 1]$). The fertility responses, the population ratios and the relative income levels are thus led by the asymmetric structure that only high-skilled workers with high fertility preference (type-$\{H, \bar{\beta}\}$) and low-skilled workers with low fertility preference (type-$\{L, \underline{\beta}\}$) respond to the counterfactual experiments.

What follows below is a detailed discussion of the policy experiments. We are particularly interested in learning the migration patterns, the fertility behavior and other important macroeconomic variables and ratios under different scenarios. To proceed, we first compute the equilibrium of the benchmark model based on the calibrated parameters. We then change the value of the relevant parameter of the concerned experiment to compute the new equilibrium, and calculate the relative changes to the benchmark model. The results on migration decisions and population ratios are summarized in Table 4. To better compare the migration patterns across policies, in Table 4 we provide the fraction of the high-skilled migrants among the total high-skilled rural workers, the fraction of the low-skilled migrants among the total low-skilled rural workers, and the fraction of all migrants among the total rural workers for each experiment. Table 5 reports the total fertility rates. It is noteworthy that in the calibration we match a half of the total fertility rates. However, to be comparable with data, the values reported in Table 5 have been multiplied by two. Finally, the income levels and the relative income ratios are presented in Table 6.

[Insert Table 4 about here]
[Insert Table 5 about here]
[Insert Table 6 about here]

1. Experiments on population policy

Two experiments are conducted here, both considering scenarios with a relaxation of the one-child policy. In the first experiment, we consider a uniform fertility constraint in both the urban and rural areas, with the constraint being set at 0.8 ($\bar{n}_U = \bar{n}_R = 0.8$) – a value that was prevalent in rural China in the benchmark model in a unisex setting.[14] Urban fertility control is thus more relaxed under this experiment. In this scenario, we find that rural workers are more willing to migrate to cities: Total rural migrants as a percentage of rural residents increases by 12.59 percent, with the high-skilled workers with high fertility preferences responding much more to such relaxation, therefore leading to a lower H^+/L^+ ratio in rural areas. As there are more high- than low-skilled workers migrating to cities, P^{H+}/P^{L+} increases, dragging down the wage for the high-skilled by 0.48 percent and slightly increasing the wage for the low-skilled by 0.44 percent. The skill premium thus decreases by 0.92 percent. Interestingly and noteworthy, both urban and rural per capita income increase. The former is due to a larger stock of high-skilled workers in urban areas, while the later is because of land reallocation owing to fewer workers in rural areas. As the childrearing costs increases with income levels, rural stayers and private sector low-skilled workers end up having fewer children. For private high-skilled workers in urban areas, even though the urban fertility control is relaxed, those workers who enjoy more from having children do not respond much to the policy by increasing their fertility. This is because of the higher child-rearing costs in urban areas. As one can observe from Table 5, the magnitude of the increases in the total fertility rates for public sector and private high-skilled workers are much less than that of the decreases in the total fertility rates for rural workers.

In the second experiment, we consider a scenario where the population control is completely lifted. Agents can have children up to their biological limit, which is set at 5.5 based on the total fertility rates in the pre-population-control period in China.[15] Total fertility rates increase both in rural and urban areas, rising from the range of 1.18 and 2.21 in the benchmark model to the range of 1.96 to 2.77. The increase in fertility is higher for rural high-skilled than rural low-skilled because the staying type-$\{H, \bar{\beta}\}$ workers respond more to the policy than type-$\{L, \underline{\beta}\}$ workers do. Along the line, rural-urban migration decreases by 2.74 percent, with the reduction in migration coming from the high-skilled workers more – indeed all high-skilled workers with high fertility preference (type-$\{H, \bar{\beta}\}$) would stay in rural areas and a fertility-based SME arises. As a result, there are fewer high-skilled workers in urban areas, leading to a lower urban per capita output, a lower rural per capita output because of more workers staying in rural areas, a slightly higher skill premium, and a higher urban-rural income gap ($\frac{y_U}{y_R}$).

2. Experiments on migration policy

We consider three scenarios for experiments on migration policy, including (i) migrants can never obtain urban residency ($\rho = 0$), (ii) migrant workers are not eligible for urban benefits even if they have obtained urban residency ($\mu = 0$ and therefore no tax payments), and (iii) migrant workers obtaining urban residency enjoy full urban benefits as urban natives ($\mu = 1$ and pay full urban

[14] Recall that the observed fertility rates are our normalized figures multiplied by two.

[15] The biological fertility limit is set at 5.5 per family. Thus, in our experiment, the limit is 5.5/2=2.75 per worker.

earmarked tax τ).

In the first and the second experiments, we encounter a corner solution – both type-$\{H, \bar{\beta}\}$ and type-$\{L, \underline{\beta}\}$ workers decide to stay in the rural. With zero low-skilled migration, rural-urban migration is simply composed by type-$\{H, \underline{\beta}\}$ migration. As a result, the skill premium in urban areas and the H^+/L^+ ratio in rural areas both decrease. Rural workers now are allocated with less arable land because of more stayers in the rural, leading to a decrease of 4.07 percent in rural per capita income. Furthermore, due to the relatively lower childrearing cost in the rural, fertility rates of rural high- and low-skilled workers increase, with the rural high-skilled fertility increases more because, among high-skilled workers, only the type-$\{H, \bar{\beta}\}$ stay in rural areas, while the low-skilled stayers comprise both preference types. The main differences between the two counterfactual experiments are only in the private high-skilled fertility and urban benefits. When migrants can never obtain urban residency in the first experiment, the private high-skilled fertility is purely contributed by urban natives. However, in the second experiment where migrants are not eligible for urban benefits but can obtain urban residency, the private high-skilled fertility is a weighted average of urban natives and new comers of purely type-$\{H, \underline{\beta}\}$ migrants. It is thus not surprising to see that in the second experiment where migrants enjoy no urban benefits, the private high-skilled workers have lower fertility.

The third experiment conducts a scenario that migrant workers who obtain urban residency enjoy full urban benefits as urban natives . Recall that in the calibration, urban benefits are financed by an urban social security tax, which is proportional to urban workers' income, and hence workers with higher incomes bear a heavier burden. However, regardless of taxes paid, all urban natives enjoy the same full urban benefits and all migrant workers who successfully obtain urban residency enjoy the same urban benefit of μB. That is, urban low-skilled workers gain from such a scheme, while urban high-skilled workers shoulder more "responsibility" in providing urban benefits. A policy of granting full benefits to rural-urban migrants upon receiving urban residency is thus undoubtedly much more attractive to low-skilled than to high-skilled migrants. Indeed, this is the result we find in the third experiment: The rural high-skilled workers who enjoy more from having children would not move to cities ($\Gamma_H = 0$) because of the foreseen tax burden and lower urban benefits enjoyed when the low-skilled counterparts flood into cities. In contrast, all rural low-skilled workers who enjoy less from having children decide to migrate to cities ($\Gamma_L = 1$) to gain the benefits. This leads to an unusual scenario of pure fertility-based SME. In this case, the P^{H+}/P^{L+} ratio decreases by 38.03 percent, resulting in an 8.3 percent increase in the skill premium. Because of the outflow of the low-skilled from the rural and the inflow of the low-skilled to the urban, urban per capita income decreases by 2.59 percent and rural per capita income increases by more than 8 percent, shrinking the urban-rural income gap by nearly 10 percent. Moreover, rural fertility rates both decrease as rural income levels increase. Our findings are in line with the international migration model of Azarnert (2019): Any migration policy inducing more migration flows to a higher income location (urban) is accompanied by lower fertility in that location.

3. Experiment on land system

Finally, we turn our attention to land reallocation policy. The land left idle by migrant workers appears to be a waste of productive resources in rural areas. To prevent the waste of productivity, people may propose to redistribute the idle land to rural stayers as soon as possible. However, land reallocation implies that rural-urban migrants would lose their land use rights. This implicit cost discourages rural-urban migration. We therefore perform two counterfactual experiments to investigate the macroeconomic effects of land reallocation policies, including (i) an immediate land reallocation policy, featuring zero land tenure security ($\delta = 0$); and (ii) a more secured land tenure policy that guarantees 15 years of land tenure ($\delta = \frac{15}{36} = 0.4167$) – that is, compared with the benchmark economy, the duration of land reallocation is doubled.

As shown in Table 5, our results show that the effects of land reallocation policies on total fertility rates are relative minor compared to other experiments. However, in Table 4, we find that the immediate loss of the entitlement of rural land deters rural-urban migration: Rural high-skilled workers who enjoy more from having children are not moving to cities anymore. The fraction of the rural low-skilled movers also drops by 13.94 percent. Thus, similar to the experiment of no population control, a fertility-based SME arises. Because of the relatively large decrease in the low-skilled migration, the skill premium decreases by 0.56 percent, but urban per capita output still increases by 0.17 percent as there are fewer lower income workers in urban areas.[16] Despite more stayers in rural areas, due to more efficient use of land, rural per capita income increases by 0.47 percent, and the urban-rural income gap is narrowed by 0.3 percent.

It is noteworthy that immediate land reallocation brings two opposing effects on the overall income level (y) in the economy: the direct effect to increase overall output per capita when land is being utilized more efficiently, and the migration discouragement effect to depress overall output per capita when there are more rural stayers. As rural per capita output is lower than urban per capita output, keeping urban and rural per capita output constant, the average overall per capita output will be lower if there are more workers in rural areas. The sum of the two opposite effects of immediate land reallocation on overall output per capita is therefore ambiguous. Our quantitative results show that the migration discouragement effect outweighs the direct effect, and the overall output per capita slightly decreases by 0.1 percent.[17]

In contrast to the immediate land reallocation policy, a guaranteed land tenure of 15 years promotes more migration for both the high- and the low-skilled, and slightly increases urban high-skilled fertility and discourages urban low-skilled fertility as more high-skilled parents who enjoy more from children and low-skilled workers enjoy less from children move to cities. Due to longer idle duration of land, the rural per capita output is slightly depressed. The urban per capita output is lowered because of more low-skilled workers in cities dragging down the average income levels, resulting in a higher skill premium. Despite the slightly lower urban and rural per capita output,

[16] The average H/L ratio is 0.1076 in 1980-2007, and rural high-skilled workers account for roughly 9.72 percent of total rural population. The decreases in the migration of rural high- and low-skilled workers are 0.16 percent and 0.67 percent in this experiment, respectively.

[17] The overall output per capita is $y = \frac{y_U U^+ + y_R R^+}{U^+ + R^+} = \frac{y_U \left\{ \frac{U}{R} + \frac{H}{R}[\zeta + (1-\zeta)\Gamma_H] + \frac{L}{R}\zeta\Gamma_L \right\} + y_R \left\{ \frac{H}{R}(1-\zeta)(1-\Gamma_H) + \frac{L}{R}[\zeta(1-\Gamma_L)+1-\zeta] \right\}}{\frac{U}{R}+1}$. Keeping y_U and y_R constant and $y_U > y_R$, when Γ_H and Γ_L are lower, $\frac{H}{R}(1-\zeta)\Gamma_H(y_U - y_R)$ and $\frac{L}{R}\zeta\Gamma_L(y_U - y_R)$ are both lower, leading to lower y.

the overall per capita output in the economy is still higher by 0.74 percent because of the migration encouragement effect.

Our results on land policy echo that of Ngai, Pissarides and Wang (2019): A less secure land tenure system is an obstacle to urbanization and industrialization in China. Our paper also corroborates with the findings of the occupational misallocation model by Gottlieb and Grobovšek (2019) that is calibrated to Ethiopia: Relaxing a "use it or lose it" land policy raises overall per capita income moderately. But different from their sorting approach, our land policy effect on the urban-rural productivity gap is reversed owing to two novel channels that work through the change in arable land supply in rural and the skill composition (hence wage premium) in urban production. Regarding the effects of land policy on fertility rates, our results are in line with that of Almond, Li and Zhang (2019): The effects of land policies (or reforms) on overall fertility rates are relatively small compared to the effects of population policies on fertility rates.

4. Summary

The above experiments all point out the presence of a locational quantity-quality trade-off of children: More migration is accompanied by a lower fertility but higher overall per capita output. No population control leads to a higher fertility for both the high- and the low-skilled, accompanied by lower migration – especially a larger reduction in the high-skilled migration and thereby a lower overall output per capita. Relaxing urban population control to rural is better than entirely removing population control as it induces more high-skilled migration, leading to higher urban output and overall output per capita. Stricter population control policies in urban areas may not be ideal in lowering fertility rates from a nationwide perspective because such a tightened fertility policy in urban areas deters high-skilled workers with high fertility preferences from migrating to cities. This is undesirable because had they migrated to urban areas and faced a higher child-rearing cost, they would have naturally adjusted their fertility down. Urban sprawl control policy such as eliminating urban benefits to all rural migrants will raise urban benefits enjoyed by workers with urban residency as planned but would grant no incentive for rural-urban migration, which is undesirable for advancing the economy. Urban promotion policy such as providing full benefit to all rural migrants would induce more migration overall but suffer "adverse-selection" by motivating much more low-skilled but less high-skilled workers to migrate. With more generous rural land entitlement, migration incentives become stronger. Rural per capita output is lower due to more idle land left behind by migrants while urban per capita output decreases due to the influx of more low-skilled workers. Nonetheless, the overall per capita output is higher due to the urban wage premium – a result that is possible because of the endogenous population weights by virtue of rural-urban migration.

To sum up, when formulating policies for developing countries, one shall not neglect policy impacts via migration and fertility responses. Overlooking the locational quantity-quality trade-off of children may lead to nonnegligible biases in assessing the consequences and effectiveness of government policies.

5 Conclusions

We have constructed a dynamic competitive migration equilibrium framework with heterogeneous agents in skills and fertility preferences to explore the macroeconomy consequences of the interplay of migration and fertility decisions. We have established a locational quantity-quality trade-off of children and found conditions to support a mixed migration equilibrium. By calibrating the model to fit the data from China, we have identified interesting interactions between fertility choices and migration decisions in various counterfactual experiments with regard to changes in migration, population control or rural land entitlement policies. We have shown that all such changes induce a locational quantity-quality trade-off of children in which more rural-urban migration is accompanied by lower fertility but higher overall per capita output.

Regarding policy implications, we have quantified that relaxing urban population control to rural is better than entirely removing population control, and stricter population control policies in urban areas may not be ideal in lowering fertility rates from a nationwide perspective. We have found that urban sprawl control may be undesirable for advancing the economy, and urban promotion policy may suffer adverse-selection by inducing more low-skilled to migrate. We have also shown that, with more generous rural land entitlement, rural per capita output and urban per capita output can both be lower but the overall per capita output of the nation can still rise as a result of increased rural-urban migration. We have thus concluded that overlooking the locational quantity-quality trade-off of children may lead to nonnegligible biases in assessing the consequences and effectiveness of government policies.

This paper is, to our best knowledge, the first to examine the dynamic interplays of migration and fertility decisions and their macroeconomic consequences. To ensure tractability and calibration with limited data, we have simplified the framework and restricted our attention to only a limited number of issues. There are thus several possible avenues to extend the current work. For brevity, we will discuss but two. First, our analysis is exclusively positive and hence possible to be generalized to allow for normative analyses, such as to examine optimal taxation or subsidy related to urban labor markets and migration, with endogenous provision of urban amenities and city government financing in a Tiebout equilibrium context as in Conley and Konishi (2002). Second, because the state of the macroeconomy changes over time, it may be valuable to examine whether a migration policy or a fertility policy may better advance the economy at different stages of economic development. Of course, to conduct these tasks would lose the tractability of the model, which is beyond the scope of the current paper.

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Table 1: Notation of Population Flow

Notation	Explanation
Beginning-of-the-period Population	
U	Total urban workers with urban residency
R	Total rural workers with rural residency
H	Rural high-skilled workers with rural residency
L	Rural low-skilled workers with rural residency
S	Public sector high-skilled workers with urban residency
P^H	Private sector high-skilled workers with urban residency
P^L	Private sector low-skilled workers with urban residency
Within-the-period Population	
U^+	Total workers working in urban areas
R^+	Total workers working in rural areas
H^+	High-skilled workers working in rural areas
L^+	Low-skilled workers working in rural areas
$\tilde{S}_F$	Migrant workers in public sector with urban residency
$\tilde{P}_F^H$	Migrant high-skilled workers in private sector with urban residency
$\tilde{P}_I^H$	Migrant high-skilled workers in private sector without urban residency
$\tilde{P}_F^L$	Migrant low-skilled workers in private sector with urban residency
$\tilde{P}_I^L$	Migrant low-skilled workers in private sector without urban residency
Fraction and Probability	
ζ	Fraction of rural population enjoying less from having children
Γ_H	Fraction of rural high-skilled workers enjoying more from children and migrating to cities
Γ_L	Fraction of rural low-skilled workers enjoying less from children and migrating to cities
π	Probability of high-skilled migrants to obtain a job in the public sector
ρ	Probability of obtaining urban residency
μ	Fraction of lifetime that migrants enjoy urban benefits

Table 2: Calibration

Parameters	Values	Target	Value of target	Explanation/Data source
Production				
z	0.4067			Solved by equation (2)
q	2.3315			Average land per person (unit: mou) from *China Statistical Yearbook*
δ	0.2083			Average land reallocation time is around 5-10 years and adjusted by the model period
A_S	2.0214	$\frac{y_U}{y_R}$	1.9641	A_S and A_P are jointly solved
A_P	3.3287	$\frac{w_S}{w_P^H}$	0.8814	A_S and A_P are jointly solved
σ	0.8333			Elasticity of substitution between high- and low-skilled workers is 6
α	0.5			Preset
η	1.3608	$\frac{w_P^H}{w_P^L}$	1.3944	Match $\frac{w_P^H}{w_P^L}$ which is taken from UHS
Preferences				
ζ	0.15			The fraction of rural families preferring less than or equal to one child in 1980s
$\underline{\beta}$	0.1			Preset
$\overline{\beta}$	0.5346	n_P^L	0.9859	$\overline{\beta}$, $\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$ are jointly solved
ε	0.1			Preset and close to Gobbi (2013)
θ	0.21			$1-\theta$ matches the average consumption rates as a percentage of disposable income in rural area
B_0	2.4863	B	0.9803	Solved by equation (38)
ψ^H	0.4230			Solved by the migration indifference equation (20)
ψ^L	0.1539			Solved by the migration indifference equation (21)
Probabilities/Duration of time				
π	0.2	$\frac{S^+}{P^{H+}}$	3.0262	π, Γ_H and Γ_L are jointly solved
μ	0.4514			Average duration to obtain urban hukou via the blue-stamp system; See Appendix C
ρ	0.11			About 11 percent of rural-urban migrants successfully obtained urban residency; See Appendix C
τ	0.2			Song, Storesletten, Wang and Zilibotti (2015)
Fraction of workers migrate				
Γ_H	0.019	$\frac{P^{H+}}{P^{L+}}$	0.6348	π, Γ_H and Γ_L are jointly solved
Γ_L	0.3576	$1-\frac{U}{U^+}$	0.1236	π, Γ_H and Γ_L are jointly solved
Fertility related				
$\bar{n}_R$	0.8			A half of average rural fertility constraint in Ebenstein (2010)
$\bar{n}_U$	0.5			A half of average urban fertility constraint in Ebenstein (2010)
$\tilde{\phi}_U^0$	0.25			Preset and in the range of the values reported in the literature; See Appendix C
$\tilde{\phi}_R^0$	0.4386	n_R^L	1.1046	$\overline{\beta}$, $\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$ are jointly solved
$\tilde{\phi}_R$	1.5928			Computed from the data provided by Ebenstein (2010)
$\tilde{\phi}_U$	1.6654			Computed from the data provided by Ebenstein (2010)
Extra penalty for high-skilled workers to have extra children				
$\tilde{\phi}_H$	5.3123	n_R^H	0.6929	$\overline{\beta}$, $\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$ are jointly solved
$\tilde{\phi}_S$	2.1439	n_S	0.5900	$\overline{\beta}$, $\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$ are jointly solved
$\tilde{\phi}_P^H$	0.2382	n_P^H	0.6728	$\overline{\beta}$, $\tilde{\phi}_R^0$, $\tilde{\phi}_H$, $\tilde{\phi}_S$ and $\tilde{\phi}_P^H$ are jointly solved

Table 3: Model Implications

Ratio	Value	Explanation
Total Factor Productivity		
A_P/A_S	1.6467	Private relative to public sector
A_P/z	8.1849	Private relative to rural agricultural sector
Fraction of Moving		
$\zeta+(1-\zeta)\Gamma_H$	0.1661	Fraction of rural high-skilled workers moving to cities
$\zeta\Gamma_L$	0.0536	Fraction of rural low-skilled workers moving to cities
Child-rearing Cost		
$\frac{\tilde{\phi}_U^0 w_S}{\tilde{\phi}_R^0 y_R}$	1.1523	Public relative to rural worker
$\frac{\tilde{\phi}_U^0 w_P^H}{\tilde{\phi}_R^0 y_R}$	1.3074	Private high-skilled relative to rural worker
$\frac{\tilde{\phi}_U^0 w_P^L}{\tilde{\phi}_R^0 y_R}$	0.9376	Private low-skilled relative to rural worker
Penalty on Above-quota Birth		
$\frac{(\tilde{\phi}_U+\tilde{\phi}_S)w_S}{(\tilde{\phi}_R+\tilde{\phi}_H)y_R}$	1.1152	Public relative to rural high-skilled worker
$\frac{(\tilde{\phi}_U+\tilde{\phi}_P^H)w_P^H}{(\tilde{\phi}_R+\tilde{\phi}_H)y_R}$	0.6323	Private high-skilled relative to rural high-skilled worker
$\frac{\tilde{\phi}_U w_P^L}{\tilde{\phi}_R y_R}$	1.7198	Private low-skilled relative to rural low-skilled worker
$\frac{(\tilde{\phi}_U+\tilde{\phi}_S)w_S}{\tilde{\phi}_R y_R}$	4.8345	Public relative to rural low-skilled worker

Table 4: Policy Experiments – Migration Decision and Population Ratios

	Γ_H	Γ_L	Fraction of H movers	Fraction of L movers	Fraction of movers	$\frac{U^+}{(U^++R^+)}$	$\frac{P^{H+}}{P^{L+}}$	$\frac{S^+}{P^{H+}}$	$1-\frac{U}{U^+}$	$\frac{H^+}{L^+}$	$\frac{S^+}{H^+}$
Benchmark Economy	0.0190	0.3576	0.1661	0.0536	0.0646	0.3584	0.6348	3.0262	0.1236	0.0948	3.4836
Population Policy											
Uniform population constraint	0.1076	0.3636	0.2415	0.0545	0.0727	0.3640	0.6710	2.8622	0.1370	0.0864	3.8495
(% change)			45.35%	1.68%	12.59%	1.56%	5.69%	-5.42%	10.87%	-8.95%	10.50%
No population control	0.0000	0.3561	0.1500	0.0534	0.0628	0.3572	0.6272	3.0640	0.1206	0.0967	3.4138
(% change)			-9.71%	-0.42%	-2.74%	-0.34%	-1.21%	1.25%	-2.41%	1.91%	-2.01%
Migration Policy											
No urban residency	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9342	3.0640	0.0308	0.0915	3.4138
(% change)			-9.71%	-100.00%	-77.43%	-9.57%	47.16%	1.25%	-75.04%	-3.53%	-2.01%
No urban benefits	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9342	3.0640	0.0308	0.0915	3.4138
(% change)			-9.71%	-100.00%	-77.43%	-9.57%	47.16%	1.25%	-75.04%	-3.53%	-2.01%
Full urban benefits	0.0000	1.0000	0.1500	0.1500	0.1500	0.4170	0.3934	3.0640	0.2467	0.1076	3.4138
(% change)			-9.71%	179.62%	132.29%	16.35%	-38.03%	1.25%	99.65%	13.49%	-2.01%
Land Policy											
Immediate loss of land entitlement	0.0000	0.3078	0.1500	0.0462	0.0563	0.3527	0.6565	3.0640	0.1094	0.0959	3.4138
(% change)			-9.71%	-13.94%	-12.88%	-1.59%	3.41%	1.25%	-11.47%	1.14%	-2.01%
15 years of guaranteed land tenure	0.1094	0.4377	0.2430	0.0656	0.0829	0.3710	0.6291	2.8590	0.1533	0.0872	3.8578
(% change)			46.28%	22.38%	28.35%	3.50%	-0.90%	-5.52%	24.01%	-8.05%	10.74%

Table 5: Policy Experiments – Total Fertility Rates

	Total Fertility Rates				
	Rural *H*	Rural *L*	Public	Private *H*	Private *L*
Benchmark Economy	1.3858	2.2091	1.1799	1.3456	1.9718
Population Policy					
Uniform population constraint	1.3321	2.1923	1.1807	1.3544	1.9610
(% change)	-3.87%	-0.76%	0.06%	0.65%	-0.55%
No population control	2.7691	2.6981	2.2690	1.9608	2.7597
(% change)	99.82%	22.13%	92.30%	45.72%	39.95%
Migration Policy					
No urban residency	1.4457	2.3011	1.1798	1.4097	1.9773
(% change)	4.32%	4.16%	-0.01%	4.76%	0.28%
No urban benefits	1.4605	2.3011	1.1798	1.3933	1.9773
(% change)	5.39%	4.16%	-0.01%	3.55%	0.28%
Full urban benefits	1.2812	2.0551	1.1798	1.2780	1.9188
(% change)	-7.55%	-6.97%	-0.01%	-5.03%	-2.69%
Land Policy					
Immediate loss of land entitlement	1.3881	2.1960	1.1798	1.3497	1.9765
(% change)	0.17%	-0.59%	-0.01%	0.30%	0.24%
15 years of guaranteed land tenure	1.3428	2.2163	1.1807	1.3460	1.9568
(% change)	-3.10%	0.32%	0.07%	0.03%	-0.76%

Note: In the numerical analysis, we match a half of total fertility rates. To be comparable with total fertility rates in data, the fertility values reported in the table have been multiplied by 2.

Table 6: Policy Experiments – Urban and Rural per capita Income, Income Ratios and Urban Benefit

	y	y_U	y_R	Income Ratios $\frac{y_U}{y_R}$	$\frac{w_S}{w_P^H}$	$\frac{w_P^H}{w_P^L}$	Urban benefit
Benchmark Economy	1.3455	1.9641	1.0000	1.9641	0.8814	1.3944	0.9803
Population Policy							
Uniform population constraint	1.3566	1.9673	1.0070	1.9536	0.8856	1.3816	0.9794
(% change)	0.82%	0.17%	0.70%	-0.53%	0.49%	-0.92%	-0.09%
No population control	1.3431	1.9634	0.9985	1.9664	0.8804	1.3972	0.9805
(% change)	-0.18%	-0.04%	-0.15%	0.12%	-0.11%	0.20%	0.02%
Migration Policy							
No urban residency	1.2945	1.9935	0.9593	2.0781	0.9096	1.3075	0.9884
(% change)	-3.79%	1.50%	-4.07%	5.80%	3.21%	-6.24%	0.83%
No urban benefits	1.2945	1.9935	0.9593	2.0781	0.9096	1.3075	0.9870
(% change)	-3.79%	1.50%	-4.07%	5.80%	3.21%	-6.24%	0.69%
Full urban benefits	1.4278	1.9132	1.0806	1.7705	0.8416	1.5102	0.9713
(% change)	6.12%	-2.59%	8.07%	-9.86%	-4.52%	8.30%	-0.91%
Land Policy							
Immediate loss of land entitlement	1.3442	1.9674	1.0047	1.9582	0.8840	1.3867	0.9812
(% change)	-0.10%	0.17%	0.47%	-0.30%	0.29%	-0.56%	0.10%
15 years of guaranteed land tenure	1.3555	1.9615	0.9982	1.9651	0.8807	1.3965	0.9782
(% change)	0.74%	-0.13%	-0.18%	0.05%	-0.08%	0.15%	-0.21%

Note: y_U is urban per capita output and y_R is rural per capita output, while y refers to overall per capita output.

Appendix (Parts B, C and D Are Not Intended for Publication)

This Appendix provides supplementary information for this paper. Four parts are included: The first part presents mathematical proofs; the second part discusses the institutional background for the regulations on the *hukou* system, land reallocation and fertility in China; data sources and detailed calibration procedures are summarized in the third part; finally, the results of the sensitivity and robustness tests are relegated to the last part.

A. Mathematical Appendix

A.1 Proof of Theorem 1 (Existence of MME)

Consider the locus $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$ where the fertility loss and the quality gain of migration balance off. Suppose we reduce the fertility loss by lowering β from $\bar{\beta}$ to $\underline{\beta}$. We then compare the expected fertility loss between $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$ and $\Delta V_H\left(\underline{\beta}, \psi^H\right)$:

$$\begin{aligned}
& \Delta V_H\left(\bar{\beta}, \psi^H\right) - \Delta V_H\left(\underline{\beta}, \psi^H\right) \\
= \;& (1-\varepsilon)\,\bar{\beta}\left\{\pi\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon} + (1-\pi)\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon} + (1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}\right] - \left(n_R^*|_{\bar{\beta}}\right)^{\varepsilon}\right\} \\
& -(1-\varepsilon)\,\underline{\beta}\left\{\pi\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon} + (1-\pi)\left[\rho\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon} + (1-\rho)\left(n_I^*|_{\underline{\beta}}\right)^{\varepsilon}\right] - \left(n_R^*|_{\underline{\beta}}\right)^{\varepsilon}\right\} \\
\propto \;& \bar{\beta}\left\{\begin{array}{c} \pi\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon} - \pi\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon} + (1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}\right] \\ +\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon} + (1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon} - \left(n_R^*|_{\bar{\beta}}\right)^{\varepsilon} \end{array}\right\} \\
& -\underline{\beta}\left\{\begin{array}{c} \pi\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon} - \pi\left[\rho\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon} + (1-\rho)\left(n_I^*|_{\underline{\beta}}\right)^{\varepsilon}\right] \\ +\rho\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon} + (1-\rho)\left(n_I^*|_{\underline{\beta}}\right)^{\varepsilon} - \left(n_R^*|_{\underline{\beta}}\right)^{\varepsilon} \end{array}\right\} \\
< \;& 0
\end{aligned}$$

because $\bar{\beta} > \underline{\beta}$ and

$$\frac{\partial}{\partial \beta}\left\{\begin{array}{c} \pi\left(n_U^*\right)^{\varepsilon} - \pi\left[\rho\left(n_U^*\right)^{\varepsilon} + (1-\rho)\left(n_M^*\right)^{\varepsilon}\right] \\ +\rho\left(n_U^*\right)^{\varepsilon} + (1-\rho)\left(n_I^*|\right)^{\varepsilon} - \left(n_R^*\right)^{\varepsilon} \end{array}\right\} < 0,$$

by Proposition 3. This yields $\Delta V_H\left(\underline{\beta}, \psi^H\right) > \Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$ so that the locus $\Delta V_H\left(\underline{\beta}, \psi^H\right)$ lies above $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$. So $\Delta V_H\left(\underline{\beta}, \psi^L\right) = 0$ lies on the right of $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$ as in Figure 5. Likewise for the location comparison for the loci $\Delta V_L\left(\underline{\beta}, \psi^L\right) = 0$ and $\Delta V_L\left(\bar{\beta}, \psi^L\right)$ in Figure 5.

For the location of the loci $\Delta V_L\left(\underline{\beta}, \psi^L\right) = 0$ and $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$ in Figure 5, we can explain as follows. Consider the loci $\Delta V_H\left(\bar{\beta}, \psi^H\right) = 0$ and $\Delta V_L\left(\underline{\beta}, \psi^H\right)$. Comparing the expected fertility loss between $\Delta V_H(\bar{\beta},\psi^H)=0$ and $\Delta V_L(\underline{\beta},\psi^H)$:

$$
\begin{aligned}
& \Delta V_H\left(\bar{\beta},\psi^H\right)-\Delta V_L\left(\underline{\beta},\psi^H\right) \\
= & (1-\varepsilon)\,\bar{\beta}\left\{\pi\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}+(1-\pi)\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}\right]-\left(n_R^*|_{\bar{\beta}}\right)^{\varepsilon}\right\} \\
& -(1-\varepsilon)\,\underline{\beta}\left[\rho\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\underline{\beta}}\right)^{\varepsilon}-\left(n_R^*|_{\underline{\beta}}\right)^{\varepsilon}\right] \\
\propto & \bar{\beta}\left\{\pi\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}-\pi\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}\right]+\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}\right]-\left(n_R^*|_{\bar{\beta}}\right)^{\varepsilon}\right\} \\
& -\underline{\beta}\left[\rho\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\underline{\beta}}\right)^{\varepsilon}-\left(n_R^*|_{\underline{\beta}}\right)^{\varepsilon}\right] \\
= & \bar{\beta}\underbrace{\left\{\pi\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}-\pi\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}\right]\right\}}_{-} \\
& +\bar{\beta}\left[\rho\left(n_F^*|_{\bar{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\bar{\beta}}\right)^{\varepsilon}-\left(n_R^*|_{\bar{\beta}}\right)^{\varepsilon}\right]-\underline{\beta}\left[\rho\left(n_F^*|_{\underline{\beta}}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\underline{\beta}}\right)^{\varepsilon}-\left(n_R^*|_{\underline{\beta}}\right)^{\varepsilon}\right] \\
< & 0,
\end{aligned}
$$

because $\bar{\beta}>\underline{\beta}$ and

$$\frac{\partial}{\partial\beta}\left[\rho\left(n_F^*|_{\beta}\right)^{\varepsilon}+(1-\rho)\left(n_I^*|_{\beta}\right)^{\varepsilon}-\left(n_R^*|_{\beta}\right)^{\varepsilon}\right]<0,$$

by Proposition 3. So the former has a larger fertility loss than the latter. Next, we compare the expected locational quality gain:

$$
\begin{aligned}
& (1-\theta)\,\theta\left\{\pi w_S+(1-\pi)\,w_P^H-\left[\pi+(1-\pi)\,\rho\mu\right]\tau-x\right\}+\left[\pi+(1-\pi)\,\rho\mu\right]B-\psi^H \\
& -\left\{(1-\theta)\,\theta\left[\rho\left(w_P^L-\mu\tau\right)+(1-\rho)w_P^L-x\right]+\rho\mu B-\psi^H\right\} \\
= & (1-\theta)\,\theta\left\{\left[\pi w_S+(1-\pi)\,w_P^H\right]-\left[\rho w_P^L+(1-\rho)w_P^L\right]\right\} \\
& -(1-\theta)\,\theta\pi\,(1-\rho\mu)\,\tau+\pi\,(1-\rho\mu)\,B \\
= & (1-\theta)\,\theta\left\{\left[\pi w_S+(1-\pi)\,w_P^H\right]-w_P^L\right\}+\pi\,(1-\rho\mu)\left[B-(1-\theta)\,\theta\tau\right] \\
> & 0.
\end{aligned}
$$

So the former has a larger locational quality gain than the latter.

Given that $\Delta V_H(\bar{\beta},\psi^H)=0$ has both a larger fertility loss and a larger locational quality gain than $\Delta V_L(\underline{\beta},\psi^H)$. Two possible cases emerge. Firstly, if $\Delta V_L(\underline{\beta},\psi^H)<0$, then the locus $\Delta V_L(\underline{\beta},\psi^L)=0$ lies below the locus $\Delta V_H(\bar{\beta},\psi^H)=0$. This is the situation shown in Figure 5 where $\psi^H>\psi^L$. Secondly, if $\Delta V_L(\underline{\beta},\psi^H)>0$, then the locus $\Delta V_L(\underline{\beta},\psi^L)=0$ lies above the locus $\Delta V_H(\bar{\beta},\psi^H)=0$ and we have $\psi^L>\psi^H$. In either case, the parametric space supporting a mixed migration equilibrium is dense and hence nonempty.■

A.2 Proof of Theorem 2 (Locational quantity-quality tradeoff)

Writing out the indifference boundaries, we have:

$$\begin{aligned}
\Delta V_H(\beta,\psi) &\equiv \pi V^S(\beta) + (1-\pi)V^{P,H}(\beta) - \psi - V^R(\beta) \\
&= \pi\left\{(1-\theta)\theta\left[w_S - \tau - n_F^*|_\beta\left[\phi_U^0 + \left(1-\frac{\bar{n}_U}{n_F^*|_\beta}\right)\bar{\phi}_U\right]\right] + \bar{\beta}\left(n_F^*|_\beta\right)^\varepsilon + B\right\} \\
&\quad + (1-\pi)\rho\left\{\begin{array}{c}(1-\theta)\theta\left[w_P^H - \mu\tau - n_F^*|_\beta\left[\phi_U^0 + \left(1-\frac{\bar{n}_U}{n_F^*|_\beta}\right)\bar{\phi}_U\right]\right] \\ +\bar{\beta}\left(n_F^*|_\beta\right)^\varepsilon + \mu B\end{array}\right\} \\
&\quad + (1-\pi)(1-\rho)\left\{\begin{array}{c}(1-\theta)\theta\left[w_P^H - n_I^*|_\beta\left[\phi_U^0 + \left(1-\frac{\bar{n}_R}{n_I^*|_\beta}\right)\bar{\phi}_R\right]\right] \\ +\bar{\beta}\left(n_I^*|_\beta\right)^\varepsilon\end{array}\right\} \\
&\quad - \left\{(1-\theta)\theta\left[x - n_R^*|_\beta\left[\phi_R^0 + \left(1-\frac{\bar{n}_R}{n_R^*|_\beta}\right)\bar{\phi}_R\right]\right] + \bar{\beta}\left(n_R^*|_\beta\right)^\varepsilon\right\} - \psi.
\end{aligned}$$

Using the optimal fertility condition (17), we obtain:

$$\begin{aligned}
\Delta V_H(\beta,\psi) &= \pi\left[(1-\theta)\theta(w_S-\tau) + (1-\varepsilon)\beta\left(n_F^*|_\beta\right)^\varepsilon + B\right] \\
&\quad + (1-\pi)\rho\left[(1-\theta)\theta\left(w_P^H - \mu\tau\right) + (1-\varepsilon)\bar{\beta}\left(n_F^*|_\beta\right)^\varepsilon + \mu B\right] \\
&\quad + (1-\pi)(1-\rho)\left[(1-\theta)\theta w_P^H + (1-\varepsilon)\bar{\beta}\left(n_I^*|_\beta\right)^\varepsilon\right] \\
&\quad - \left[(1-\theta)\theta x + (1-\varepsilon)\bar{\beta}\left(n_R^*|_\beta\right)^\varepsilon\right] - \psi \\
&= \underbrace{\begin{array}{c}(1-\theta)\theta\left\{\pi w_S + (1-\pi)w_P^H - [\pi + (1-\pi)\rho\mu]\tau - x\right\} \\ + [\pi + (1-\pi)\rho\mu]B - \psi\end{array}}_{\text{expected locational quality gain (+)}} \\
&\quad + \underbrace{(1-\varepsilon)\beta\left\{\pi\left(n_F^*|_\beta\right)^\varepsilon + (1-\pi)\left[\rho\left(n_F^*|_\beta\right)^\varepsilon + (1-\rho)\left(n_I^*|_\beta\right)^\varepsilon\right] - \left(n_R^*|_\beta\right)^\varepsilon\right\}}_{\text{expected fertility loss (-)}}.
\end{aligned}$$

Likewise, we have:

$$\begin{aligned}
\Delta V_L(\beta,\psi) &= V^{P,L}(\beta) - \psi - V^R(\beta) \\
&= \underbrace{(1-\theta)\theta\left[\rho\left(w_P^L - \mu\tau\right) + (1-\rho)w_P^L - x\right] + \rho\mu B - \psi}_{\text{expected locational quality gain (+)}} \\
&\quad + \underbrace{(1-\varepsilon)\beta\left[\rho\left(n_F^*|_\beta\right)^\varepsilon + (1-\rho)\left(n_I^*|_\beta\right)^\varepsilon - \left(n_R^*|_\beta\right)^\varepsilon\right]}_{\text{expected fertility loss (-)}}.
\end{aligned}$$

So the indifference boundaries can be decomposed into two terms: an expected locational quality gain versus an expected fertility loss.

For the expected locational quality gain, it is straightforward to show that it is positive. Given that urban amenities B are non-rival and non-excludable, whereas τ is the individual embarked tax, we get $B > \tau$. Also, since migration cost is a fraction of wage incomes, so the overall locational gain must be positive. For the expected fertility loss, Proposition 3 implies that it is negative. As a result, we obtain a locational quantity-quality tradeoff for the migration decision.■

B. Institutional Background in China

B.1 The *Hukou* System

In the 1950s, China implemented an unique *hukou* system to solve the serious problem of rural-urban labor migration. The *hukou* system required everyone to register in one and only one place of his/her residence. A formal rural-urban migration required both appropriate documents and a migration permit (quota) issued by the government. The regular channels of rural-urban migration included recruitment by a state-owned enterprise (*zhaogong*), enrolment in an institution of higher education (*zhaosheng*), promotion to a senior administrative job (*zhaogan*), and displacement due to state-initiated land expropriation (*zhengdi*). Because the government tightly controlled the annual migration quotas and the *hukou* registration could not be changed freely, the *hukou* system formed a dual structure with no labor mobility but urban-rural distinctions.

The *hukou* system not only restricted internal migration itself, but also integrated with social and economic controls. In rural areas, adults were bound to the land. They were belonged to communes and had to participate in agricultural production to obtain food rations for their households. For urban residents, work units were the primary administrative units to assign most social services. For example, a work unit determined grain rations, education for children, health benefits, and purchasing house. The above controls were effective because, in the pre-reform period, local governments predominated the distribution of daily necessities. Few of them were traded in the market. Besides, there were few urban jobs outside the state-owned enterprises. Therefore, it was difficult to survive outside one's *hukou* registration place without a work unit and a formal urban *hukou*.

Since 1980s, due to the economic reform, the growing market-oriented economy demanded more cheap labor. It became easier for people to find city jobs in private sectors and survive outside their *hukou* registration place. In addition, the economic reform also forced the government to relax the administrative control, such as the abolition of food rations and the commune system. These factors increased rural-urban migration and resulted in a significant temporary migration (floating population, who stayed outside their *hukou* registration place). The noticeable mobility forced the government to have its *hukou* regulation reforms. For example, temporary residence certificate was introduced to all urban areas in 1985 and extended to rural areas in 1995; local governments allowed "self-supplied food grain" urban *hukou*; and the "blue-stamp" urban *hukou* was conducted in the 1990s. Finally, in 2014, the central government announced to gradually implement unified urban-rural household registration system.

B.2 Land Reallocation and Migration

As mentioned in Section B.1, rural adults were bound to lands and were belonged to communes. Because rural production could not be freely traded in the market, rural people had low incentives to work. To motivate rural production, household responsibility system (HRS) was introduced to replace the rural commune system in the early 1980s. Under the HRS, village collectives officially owned the land and distributed the use rights to households. Households only had fixed-term contracts to use land for production activities. Besides, the government gave each household a quota of goods to produce. Households received compensation for the quota. Above-quota production could be sold in the market at unregulated prices. This system motivated households to work harder and successfully increased rural production in a short period of time.

The distribution of land use rights was mainly based on population size within a household.

After several years, village collectives had the right to reallocate land according to changes of household size. Therefore, the land rights for rural households were incomplete and the land tenure arrangement interacted with rural-urban migration decisions in the following ways. First, rural-urban migration resulted in a risk of land expropriation in the next land reallocation because rural-urban migration decreased household size, especially permanent migration. Second, it was unclear if households had the rights to rent the land they obtained or to transfer the contract. Since households did not have the property right of land, land could not be sold when households migrated to cities and might become idle land. This represented the opportunity cost of rural-urban migration.

To strengthen land tenure security, the Land Management Law and the Rural Land Contracting Law (RLCL) were implemented in 1998 and 2002, respectively. These laws focused on three reforms: (i) The duration of land contract should be 30 years; (ii) Large scale of land reallocations are not allowed. Only small-scale adjustments with clear conditions are agreed; (iii) Land transfer between households is permitted. However, despite the above land reforms, previous studies show that households remained facing the risk of land reallocation.[18] On one hand, land expropriation is exacerbated due to urban expansion and infrastructure development. On the other hand, although land transfers are allowed after the reforms and the transfers do not affect the underlying contracts with the village collectives, the transfer market for land is still immature. Transfer contracts remain informal and are usually made with relatives.

B.3 The One-child Policy and Migration

In the early 1970s, China introduced the "Later, Longer, and Fewer" family planning program to lower the fast population growth. However, the program did not successfully reach the ideal population growth rate. To quickly achieve the goal, the central government implemented the well-known one-child policy in 1979. The strict one-child policy successfully lowered China's total fertility rate to be less than two. However, when the one-child generation grew up, it was realized that the fast decline in fertility will result in a fast demographic change, shortage of labor force, and rapid population aging in the near future.[19] Thus, the one-child policy was eventually abolished in 2015.

The principle of the one-child policy restricted each couple to have only one child. The policy was introduced by the central government but the implementation was conducted by local governments. Thus, the detailed rules differed between provinces, areas, and ethnic groups. In some provinces and ethnic minorities, more than one child was permitted under some special conditions. In principle, the implementation contained benefits for one-child families and penalties on the above-quota birth. The benefits and subsidies that one-child families could obtain included child allowance, priority access to schools, employments, health care, and housing. In rural areas, one-child families could even enjoy tax credit and receive more land. In contrast, the penalties on above-quota births would be 10-20 percent of family income lasting for 3-14 years. In particular, if parents worked in public sectors, which included the government sector and the state-owned enterprises, they would not eligible for promotion, be demoted or be forced to quit their jobs. Moreover, the above-quota children were not allowed to attend public schools.

[18] For example, Deininger and Jin (2009) find that about 1/3 households out of their sample experienced land reallocations during 2002-2004. Tao and Xu (2007) find similar evidence.

[19] Liao (2013) employs a general-equilibrium model to study the long-run macroeconomic effects of imposing the one-child policy in China.

The one-child policy also interacted with the *hukou* system and had impacts on migration decisions. Permanent migrants (formal rural-urban migration) had to follow the fertility policies of their destination cities but usually a transition period was allowed. The transition period ranged from two to five years. The rules in some cities were even stricter. For example, if the wife had not been pregnant when a couple obtained Beijing *hukou*, the certificate for having a second child they received in rural areas would be withdrawn. In contrast, fertility decisions of temporary migrants of course were restricted by their original places. However, the family planning officials who were responsible for temporary migrants' fertility had difficulty on tracking where the migrants move to. Thus, the growing amount of temporary migrants increased the difficulty of implementing the one-child policy in China.

C. Data for Calibration

- Retirement age

  The statutory retirement age in China is relatively young compared to other countries. The normal retirement age has been set at 60 years for men, 50 years for blue collar women and 55 years for white collar women in China since the 1950s. It is possible to claim a pension benefit from the age of 55 for men and 50 for women if the individual engaged in physical work in certain industries or posts (OECD, 2019).

- Population

  High-skilled workers refer to those whose education level are senior high school or above. Those below senior high school level are classified as low-skilled workers.

  - Urban and rural population (U and R)

    The data of urban and rural population is directly obtained from *China Population and Employment Statistics Yearbook* 2010. We compute the urban-rural population ratios ($\frac{U}{R}$) for the years of 1980-2007. The average from 1980 to 2007 is 0.4579.

  - Rural high- and low-skilled population (H and L)

    China Rural Statistical Yearbook 1987-2008 report the statistics of rural workers' educational attainment. Using our definition of high-skilled workers, we thus compute the rural high-to-low-skilled ratio ($\frac{H}{L}$) for the years from 1985 to 2007. However, the data before 1985 is not available. We back out the ratios for 1980-1984 by the following steps. First, we compute the annual growth rate of the rural high-to-low-skilled ratio from 1985 to 2007 and the geometric average is 3.728 percent. Second, with the rural high-to-low-skilled ratio in 1985 and the average annual growth rate, we are able to calculate the rural high-to-low-skilled ratio from 1980 to 1984. The average of $\frac{H}{L}$ during 1980-2007 is then equal to 0.1076.

  - Urban public and private employment (S and P)

    The number of urban employments by sectors is available in *China Statistical Yearbook*. We define state-owned units as urban public sector and others (including collective-owned units, cooperative units, joint ownership units, limited liability corporations, share holding corporations Ltd., private enterprises, units with funds from Hong Kong, Macao and Taiwan, foreign funded units, and self-employed individuals) to be urban private sectors. Then we obtain the urban public-private employment ratio ($\frac{S}{P}$) for the years of 1980, 1985, 1990, 1995-2007. For the years without data (1981-1984, 1986-1989, and

1991-1994), we use linear interpolation to back out the corresponding urban public-private employment ratios. The average of $\frac{S}{P}$ during 1980-2007 is 1.5235. In addition, we also use the number of urban employments by sectors to compute the public-urban population ratio, $\frac{S}{U}$. According to the definition in our model, $U = S + P$. We thus use the number of employment in state-owned units as the numerator and the sum of employment in state-owned units and other units as the denominator to obtain $\frac{S}{U}$. Similarly, the years without data are backed up by linear interpolation. The average of $\frac{S}{U}$ during 1980-2007 is 0.6094.

– Urban private high- and low-skilled population (P^H and P^L)

  Urban Household Survey (UHS) provides the number of urban workers on two dimensions: workers' employment types and their education levels. We thus use UHS to compute the private high- to low-skilled worker ratio ($\frac{P^H}{P^L}$) with the following steps. First, we define workers in other economic units, private entrepreneurs in cities and towns, employees in private businesses and other employments as private sectors, while those who already retired but re-entered the labor force are excluded. Second, given our definition of high-skilled workers, we compute the number of high-skilled and low-skilled workers in private sectors and the ratio of high- to low-skilled workers for 1987-2007. Third, for the years without data (1980-1986), we calculate the annual growth rate of $\frac{P^H}{P^L}$ from 1987 to 2007 and have the geometric average growth rate. Then, linear interpolation is implemented to obtain the ratio of high- to low-skilled workers during 1980-1986. Finally, we obtain the average of $\frac{P^H}{P^L}$ during 1980-2007, which is 0.8159.

– Urban population (U) and the number of workers actually work in urban areas (U^+)

  Urban population (U) is directly obtained from *China Population and Employment Statistics Yearbook* 2010. The difference between U and U^+ is rural-urban floating population. As rural-urban migrants was the majority in China's internal migration, we assume the entire floating population reported in data is the rural-urban migrants. Using the floating population of 1982, 1987, 1990, 1995, 2000 and 2005 provided by Department of Population and Employment Statistics, National Bureau of Statistics of China (2008, appendix table 1), we first calculate the corresponding ratios of floating to urban population. Second, linear interpolation is implemented to compute the ratios for the years that the data is not available. For the year of 1980 and 1981, we calculate the two ratios based on the year of 1982 and the geometric average on annual growth rate of floating-to-urban population ratio during 1982-1987. Similarly, the ratios of 2006 and 2007 are computed based on the year of 2005 and the geometric average on annual growth rate of floating-to-urban population ratio during 2000-2005. Now we have a series of floating-to-urban population ratio from 1980 to 2007. Third, the floating-to-urban population ratios are converted to $\frac{U}{U^+}$ and the average of $\frac{U}{U^+}$ during 1980-2007 is 0.8764.

– Workers that actually work in urban areas (P^{H+}, P^{L+}, and S^+)

  To compute the workers that actually work in each sector, we need to know the floating population working in each sector. Unfortunately, the data is not observed. Using the Rural-Urban Migrant Survey (RUMS), Li (2010) estimates that the proportion of migrant workers employed as production workers, service workers, private enterprise owners, or self-employed reached 93 percent in 2007, while 81 percent of them were employed in private enterprises or self-employed. Based on this information, we can infer that roughly 7 percent of migrants worked in the public sector in 2007, while at most 12 percent of migrants were private business owners. As it was relatively inflexible for the public sector to hire migrants in early years and our data period spans from 1980 to 2007, it is natural to see the 7 percent of migrants working in the public sector as an upper bound. We thus assume that 5 percent of the entire floating population ended up with jobs in public sector, 20 percent worked as high-skilled workers in private sectors and the rest (75 percent) found jobs as private low-skilled workers. Then we are able to compute the workers that actually work in urban areas ($\frac{P^{H+}}{P^{L+}}$ and $\frac{S^+}{P^{H+}}$) by the above population ratios and the population identity below:

$$\begin{aligned}\frac{P^{H+}}{P^{L+}} &= \frac{P^{H+}/U^+}{P^{L+}/U^+} = 0.6348,\\ \frac{S^+}{P^{H+}} &= \frac{S^+/U^+}{P^{H+}/U^+} = 3.0262,\end{aligned}$$

where

$$\begin{aligned}\frac{P^{H+}}{U^+} &= [\frac{P^H}{U} + \frac{\tilde{P}_F^H}{U} + \frac{\tilde{P}_I^H}{U}]\frac{U}{U^+} = \frac{P^H}{U}\frac{U}{U^+} + 0.2(1 - \frac{U}{U^+}),\\ \frac{P^{L+}}{U^+} &= [\frac{P^L}{U} + \frac{\tilde{P}_F^L}{U} + \frac{\tilde{P}_I^L}{U}]\frac{U}{U^+} = \frac{P^L}{U}\frac{U}{U^+} + 0.75(1 - \frac{U}{U^+}),\\ \frac{S^+}{U^+} &= [\frac{S}{U} + \frac{\tilde{S}_F}{U}]\frac{U}{U^+} = \frac{S}{U}\frac{U}{U^+} + 0.05(1 - \frac{U}{U^+}),\\ \frac{P^H}{U} &= (1 - \frac{S}{U})(\frac{P^H/P^L}{1 + P^H/P^L}),\\ \frac{P^L}{U} &= (1 - \frac{S}{U})(\frac{1}{1 + P^H/P^L}).\end{aligned}$$

- Workers that actually work in rural areas (R^+)

  To obtain the $\frac{R}{R^+}$, the following population identities are applied. First, we define $\tilde{U} = \tilde{S}_F + \tilde{P}_F^H + \tilde{P}_F^L + \tilde{P}_I^H + \tilde{P}_I^L$ and thus we have $R^+ = R - \tilde{U}$ and $\frac{R}{R^+} = \frac{1}{1-\frac{\tilde{U}}{R}}$. Similarly, in urban areas, we know that $\frac{U}{U^+} = \frac{U}{U+\tilde{U}} = \frac{1}{1+\frac{\tilde{U}}{U}}$. Rearrange to obtain $\frac{\tilde{U}}{U} = \frac{U^+}{U} - 1$. Therefore, $\frac{\tilde{U}}{R} = \frac{\tilde{U}}{U}\frac{U}{R} = (\frac{U^+}{U} - 1)\frac{U}{R}$. Finally, we have:

$$\frac{R}{R^+} = \frac{1}{1 - \frac{\tilde{U}}{R}} = \frac{1}{1 - (\frac{1}{U/U^+} - 1)\frac{U}{R}}$$

  With the ratios of $\frac{U}{U^+}$ and $\frac{U}{R}$ mentioned above, we have the average of $\frac{R}{R^+} = 1.069$ or $\frac{R^+}{R} = 0.9354$ during 1980-2007.

- Rural land

  - Duration of land reallocation (δ)

    According to Article 27 of *Notes to Law of the People's Republic of China on Land Contract in Rural Areas (Zhonghua Renmin Gongheguo nong cun tu di cheng bao fa shi yi)* implemented in 2003, the duration of land reallocation in general should be between 5 to 10 years. To have a representative value of the duration, we thus take the average and adjust by the model period to obtain $\delta = \frac{(5+10)/2}{36} = 0.2083$.

- Land per person (q)

  The data of average land per person is taken from *China Statistical Yearbook* 1987-2007 and *Area of Land Managed by Rural Households* in National Data provided by National Bureau of Statistics of China. Average land per person includes two items: area of cultivated land under management by rural households and hilly area under management by rural households. The average of 1980-2007 is 2.3315 mou per person.

- Wages

  - Rural per capita income (y_R)

    It is normalized to one during 1980-2007.

  - Urban wages (w_S, w_P^H, and w_P^L)

    Similar to the number of urban workers, UHS also provides information on workers' income. We thus use UHS to compute urban income in each sector with the following steps. First, we define workers in other economic units, private entrepreneurs in cities and towns, employees in private businesses and other employments as private sectors, while those working in state-owned units and collective economic units in cities and towns are classified as public sectors. We exclude those who already retired but re-entered the labor market. Second, we only consider wage-related income to be a worker's wage here. Third, given our definition of high-skilled workers, we are able to compute the average wage of high-skilled workers from 1987 to 2007. Similarly, the average wage of low-skilled workers from 1987 to 2007 are calculated. Then we obtain a series of skill premium ($\frac{w_P^H}{w_P^L}$) during 1987-2007. Fourth, for the years without data (1980-1986), we calculate the annual growth rate of skill premium from 1987 to 2007 and have the geometric average growth rate. Interpolation is implemented to obtain the skill premium during 1980-1986. Thus the average skill premium during 1980-2007 is 1.3944. Finally, using the definition of public sectors, we obtain the average wage of workers in public sector during 1987-2007. A series of $\frac{w_S}{w_P^H}$ during 1987-2007 is computed. Based on the data of 1987 and the geometric average growth rate, we obtain $\frac{w_S}{w_P^H}$ for the period between 1980-1986. Therefore, the average $\frac{w_S}{w_P^H}$ during 1980-2007 is 0.8814.

  - Urban premium ($\frac{y_U}{y_R}$)

    Table 10-2 in *China Statistical Yearbook 2011* reported disposable income per capita in urban and rural areas for 1978, 1980, 1985, and 1990-2007. We obtain urban and rural real per capita income by considering price changes (the base year is 1978). Then, urban premium (the ratio of urban-rural real per capita income) of 1980, 1985 and 1990-2007 are obtained. For the years without data (1981-1984 and 1986-1989), linear interpolation is applied to compute the corresponding urban and rural real per capita income. Then, the urban premium is computed accordingly. With the entire series, we then compute the average of urban premium from 1980 to 2007, which is 1.9641.

- Altruistic factor (θ)

  We adopt Leontief preference in the theoretical model and obtain the relation $\frac{c}{nb} = \frac{1-\theta}{\theta}$. This implies that $\theta = \frac{1}{\frac{c}{nb}+1}$. To calibrate θ, we use the information on average rural per capita income and consumption in China Statistical Yearbook. The rural consumption-income ratio is obtained by average consumption expenditure minus average expenditure on educational and recreational activities and other expenditure over average rural income. The rural saving-income ratio is average rural income minus average consumption expenditure over average rural income. All are in per capita term. With the series of the rural consumption-income ratio and the rural saving-income ratio, we are able to compute the consumption-saving ratio ($\frac{c}{nb}$) and obtain a series of θ during 1980-2007. The average of θ from 1980 to 2007 becomes 0.2124.

- Imputed fertility (n_R^L, n_R^H, n_P^L, n_P^H, and n_S)

  For calibration, we need the fertility of parent with different skill types and working in different sectors. Unfortunately, the corresponding data is not available. We thus adopt the total fertility rates by education levels in Retherford, Choe, Chen, Li, and Cui (2005) to be the base and use population distribution of education level in rural, urban, or public sector as a weight to compute a weighted fertility for each type. The population distributions of education level in rural areas are obtained from *China Rural Statistical Yearbook* 1987-1995 and 1997-2008. The population distributions of education level in urban areas are from *China Population Statistics Yearbook* 1988, *10 Percent Sampling Tabulation on the 1990 Population Census of the People's Republic of China*, *1995 China 1% Population Sample Survey*, and *The Tabulation on the 2000 Population Census of the People's Republic of China*. For those who work in public sector, census data is not available. We thus use the information of public-sector workers' education levels in UHS to compute the distribution. The definition of public sector is the same as that in calculating w_S (those working in state-owned units and collective economic units in cities and towns). Specifically, to be consistent with the assumption in our theoretical model, we only consider those whose education level are senior high school or above when n_S is computed. The imputed fertility in various years are reported in Table C.1.

[Insert Table C.1 about here]

- Our quantitative analysis studies the period of 1980-2007. However, the last total fertility rate that Retherford, Choe, Chen, Li, and Cui (2005) reported is that of 1996-2000. Thus, our imputed fertility also ends in 1996-2000. Besides, in our theoretical framework, we assume there is only one parent in a household. We therefore match a half of the imputed fertility in Table C.1 in the calibration.

- Basic above-quota penalty ($\bar{\phi}_R$ and $\bar{\phi}_U$)

  Because the above-quota penalty could be non-monetary and there is no suitable measurement to measure the overall above-quota penalty, we assume low-skilled workers bear the basic above-quota fine $\bar{\phi}_R$ in rural areas and $\bar{\phi}_U$ in urban areas. Define $\tilde{\phi}_R$ to be the proportion of basic above-quota fine to a rural agent's wage and $\tilde{\phi}_U$ is the proportion of basic above-quota fine to an urban agent. Then, we use the information provided by Ebenstein (2010) to impute $\tilde{\phi}_R$ and $\tilde{\phi}_U$ by the following steps. First, Ebenstein (2010) provides above-quota fine rates and fertility policies for provinces in China during 1979-2000. If the fertility policy of a province in a year is equal to one, the province in that year is classified as urban areas; otherwise, a province is defined to be rural areas if its fertility policy is greater than one. Following this classification, we have two subgroups: rural and urban groups. Second, we compute the simple average of the above-quota fines in the urban group to obtain $\tilde{\phi}_U = 1.6654$. Similarly, the simple average of the above-quota fines in the rural group is $\tilde{\phi}_R = 1.5928$.

- Urban child rearing cost as a percentage of urban per capita income ($\tilde{\phi}_U^0$)

  As there is no nationwide survey on urban child rearing cost in China during the period of 1980-2007, we are forced to rely on estimates and surveys for selected cities in China. According to Ye and Ding (1998), the total raising cost of a child from age 0 to 16 accounts for 34 percent and 20 percent of family income for Ximen and Beijing during 1995-1996, respectively. Zhang (2000) reports that for Zhengzhou in 1998, 56 percent of households spent less than 30 percent of family income on child. We therefore set $\tilde{\phi}_U^0$ at 25 percent, a value falling within the range of the figures reported by Ye and Ding (1998) and Zhang (2000).

- Proportion of rural households enjoying less from having children (ζ)

  Table 1 in Hermalin and Liu (1990) provides percent distribution of family size preferences in surveys in selected areas of China with various years. We define people who desire less than or just one child as $\underline{\beta}$-type agents and focus on rural or suburban areas. Then, the proportion of rural households enjoying less from having children is around 15.37%. Besides, Table 19 in Scharping (2003) also reports surveys on family size preferences for 1980-1997. Following the same definition of $\underline{\beta}$-type agents and focus on rural or suburban areas, we obtain 15.29%. Based on these two results, we set $\zeta = 0.15$.

- Probability of obtaining urban residency (ρ) and the fraction of lifetime to enjoy urban benefits/pay urban embarked tax (μ)

  Regarding the parameters for the institution of the *hukou* system, μ and ρ, we resort to the literature. Prior to 1994, it was very difficult for rural migrants to obtain urban *hukou*. The blue-stamp system, implemented in 1994, opened the door to rural migrants. According to Liu (2005), it took two to five years for rural migrants to get urban *hukou* via the blue-print system. We therefore compute μ based on this information. Assume that rural migrants who worked in urban private sector were not qualified for urban benefits prior to 1994 because they could not obtain urban *hukou*, i.e. $\mu = 0$ prior to 1994. After 1994, due to the relaxation of the blue-print system, it took an average of $\frac{2+5}{2} = 3.5$ years for a migrant to obtain urban residency and hence to be qualified for urban benefits. The period we examine is 1980-2007, and 1980-1994 roughly amounts to half of the examined period. Therefore, the average μ, the fraction of lifetime that a migrant worker successfully obtained urban residency to enjoy urban benefits, is $1 - \frac{0+3.5}{2}/36 = 0.4514$ for the period of 1980 to 2007. As for ρ, according to Wu and Treiman (2004), only about 11 percent of the interviews from rural areas successfully obtained urban residency. We thus set ρ at 0.11.

- Urban benefit (B)

  There is no perfect measure to proxy urban benefit. We thus use retirement benefit to represent urban benefit. The retirement benefit is the sum of pension he or she receives during the years that a retired agent is still alive. During the periods that we study, the life expectancy was about 75 years and the average retirement age was 53 years old. Besides, the average replacement rate (for all retirees) in China's pension system from 1980-1995 was about 81.67%, as reported in Table 2 of West (1999). Therefore, we obtain the urban benefit using the replacement rate multiplied by urban per capita income (model value) and the number of alive years after retirement. The urban benefit is adjusted by the model period and $B = 0.9803$.

D. Sensitivity and Robustness Tests

In Section 4.2, to compute workers that actually work in each sector, we have assumed that 5 percent of the entire floating population ended up with jobs in public sector, 20 percent worked as high-skilled workers in private sectors, and the rest (75 percent) found jobs as private low-skilled workers. In this appendix we provide the sensitivity and robustness tests for this assumption.

Recall that the ratios of the stocks of the sectoral specific within-the-period workers change as the assumption on the fractions of floating population in each sector change. As we have targeted the ratios of the stocks of the within-the-period workers in calibration, altering the assumption means that we have to recalibrate the model. For easy communication, in the following, we will call the calibration in the main text the "benchmark calibration."

Denote φ_S, φ_P^H and φ_P^L as the fractions of the floating population ending up working as public sector, private sector high- and private sector low-skilled workers, where $\varphi^S + \varphi_P^H + \varphi_P^L = 1$. Based on the data in Li (2010), we consider four plausible assumptions on φ_S, φ_P^H and φ_P^L: (1) $\varphi_S = 5\%$, $\varphi_P^H = 22\%$ and $\varphi_P^L = 73\%$; (2) $\varphi_S = 5\%$, $\varphi_P^H = 18\%$ and $\varphi_P^L = 77\%$; (3) $\varphi_S = 7\%$, $\varphi_P^H = 20\%$ and $\varphi_P^L = 73\%$; and (4) $\varphi_S = 3\%$, $\varphi_P^H = 20\%$ and $\varphi_P^L = 77\%$. The first two robustness tests fix φ_S at the value in the benchmark calibration while alter φ_P^H and φ_P^L by 2 percent, and the later two robustness tests fix φ_P^H at 20% as in the benchmark calibration, adjusting φ_S and φ_P^L by 2 percent. Table D.1 reports the summary of the calibrated parameters and variables under the four assumptions. Table D.2 shows the relative productivity, relative child rearing costs and relative above-quota penalties, fractions of moving, population ratios, total fertility rates and income ratios for the four robustness tests. Table D.3 presents the policy experiment results under the four assumptions. For easy comparison, we provide in each table the values of the benchmark calibration.

[Insert Table D.1 about here]
[Insert Table D.2 about here]
[Insert Table D.3 about here]

Not surprisingly, the probability of being recruited as public workers π and the fractions of workers migrating to cities Γ_H and Γ_L change as the assumption on the fractions of floating population in each sector change; so do the ratios of the within-the-period worker stocks. As we have targeted the same urbanization rates, fertility rates, income ratios and fraction of newly moved, the benchmark calibration and the four robustness tests display very similar relative productivity, relative child rearing costs and relative above-quota penalties, and the same model implied urbanization rates, fertility rates, fraction of moving, population ratios and income ratios.

Next we move to the results of the policy experiments under the four different assumptions. As shown in Table D.3, rural and urban per capita output, relative income ratios such as urban wage premium and skill premium all exhibit the same direction of movements as what is observed in the policy experiments of the benchmark calibration. The variable that we have mixed signs is the overall output per capita under the experiment of immediate reallocation of land. As being discussed in Section 4.3, this is a result from endogenous fractions of migration: If the migration discouragement effect of more workers staying in rural areas outweighs the direct effect of the increases in both the rural and urban per capita output, the overall output per capita will decrease, and vice versa. To sum up, our results are quite robust.

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Table C.1: Imputed Fertility

Period	1981-1985	1986-1990	1991-1995	1996-2000	Average
n_R^L	3.0154	2.5287	1.8003	1.4921	2.2091
n_R^H	1.7965	1.6545	1.0777	1.0145	1.3858
n_P^L	2.4576	2.3464	1.6868	1.3965	1.9718
n_P^H	1.7839	1.5721	1.0526	0.9739	1.3456
n_S	-	1.5344	1.0426	0.9628	1.1799

Table D.1: Robustness Tests for Calibration

Parameters	Benchmark	Target	Target value	Robustness 1 $\varphi_S = 5\%, \varphi_P^H = 22\%, \varphi_P^L = 73\%$		Robustness 2 $\varphi_S = 5\%, \varphi_P^H = 18\%, \varphi_P^L = 77\%$		Robustness 3 $\varphi_S = 7\%, \varphi_P^H = 20\%, \varphi_P^L = 73\%$		Robustness 4 $\varphi_S = 3\%, \varphi_P^H = 20\%, \varphi_P^L = 77\%$	
				Parameter value	Affected target	Parameter value	Affected target	Parameter value	Affected target	Parameter value	Affected target
Production											
z	0.4067			0.4067		0.4067		0.4067		0.4067	
q	2.3315			2.3315		2.3315		2.3315		2.3315	
δ	0.2083			0.2083		0.2083		0.2083		0.2083	
A_S	2.0214	$\frac{y_U}{y_R}$	1.9641	2.0198		2.0231		2.0205		2.0224	
A_P	3.3287	$\frac{w_S}{w_P^H}$	0.8814	3.3189		3.3385		3.3243		3.3330	
σ	0.8333			0.8333		0.8333		0.8333		0.8333	
α	0.5			0.5		0.5		0.5		0.5	
η	1.3608	$\frac{w_P^H}{w_P^L}$	1.3944	1.3670		1.3547		1.3632		1.3585	
Preferences											
ζ	0.15			0.15		0.15		0.15		0.15	
$\underline{\beta}$	0.1			0.1		0.1		0.1		0.1	
$\overline{\overline{\beta}}$	0.5346	n_P^L	0.9859	0.5336		0.5356		0.5338		0.5354	
ε	0.1			0.1		0.1		0.1		0.1	
θ	0.21	B	0.9803	0.21		0.21		0.21		0.21	
B_0	2.4863			2.4882		2.4844		2.4869		2.4858	
ψ^H	0.4230			0.4104		0.4376		0.4706		0.3670	
ψ^L	0.1539			0.1533		0.1537		0.1534		0.1536	
Probabilities/Duration of time											
π	0.2	$\frac{S^+}{P^{H+}}$	3.0262	0.1852	2.9848	0.2174	3.0686	0.2593	3.0400	0.1304	3.0123
μ	0.4514			0.4514		0.4514		0.4514		0.4514	
ρ	0.11			0.11		0.11		0.11		0.11	
τ	0.2			0.2		0.2		0.2		0.2	
Fraction of workers migrate											
Γ_H	0.0190	$\frac{P^{H+}}{P^{L+}}$	0.6348	0.0346	0.6493	0.0033	0.6206	0.0346	0.6405	0.0033	0.6293
Γ_L	0.3576	$1-\frac{U}{U^+}$	0.1236	0.3481		0.3672		0.3481		0.3672	
Fertility related											
$\bar{n}_R$	0.8			0.8		0.8		0.8		0.8	
$\bar{n}_U$	0.5			0.5		0.5		0.5		0.5	
$\tilde{\phi}_U^0$	0.25			0.25		0.25		0.25		0.25	
$\tilde{\phi}_R^0$	0.4386	n_R^L	1.1046	0.4376		0.4396		0.4378		0.4394	
$\tilde{\phi}_R$	1.5928			1.5928		1.5928		1.5928		1.5928	
$\tilde{\phi}_U$	1.6654			1.6654		1.6654		1.6654		1.6654	
Extra penalty for high-skilled workers to have extra children											
$\tilde{\phi}_H$	5.3123	n_R^H	0.6929	5.2045		5.4219		5.3238		5.2945	
$\tilde{\phi}_S$	2.1439	n_S	0.5900	2.1406		2.1463		2.1216		2.1696	
$\tilde{\phi}_P^H$	0.2382	n_P^H	0.6728	0.2319		0.2447		0.2381		0.2371	

Table D.2: Robustness Tests for Model Implications

Ratio	Benchmark	Robustness 1	Robustness 2	Robustness 3	Robustness 4
		$\varphi_S = 5\%$, $\varphi_P^H = 22\%$, $\varphi_P^L = 73\%$	$\varphi_S = 5\%$, $\varphi_P^H = 18\%$, $\varphi_P^L = 77\%$	$\varphi_S = 7\%$, $\varphi_P^H = 20\%$, $\varphi_P^L = 73\%$	$\varphi_S = 3\%$, $\varphi_P^H = 20\%$, $\varphi_P^L = 77\%$
Total Factor Productivity					
A_P/A_S	1.6467	1.6432	1.6502	1.6453	1.6480
A_P/z	8.1849	8.1608	8.2090	8.1742	8.1955
Fraction of Moving					
$\zeta + (1-\zeta)\Gamma_H$	0.1661	0.1794	0.1528	0.1794	0.1528
$\zeta\Gamma_L$	0.0536	0.0522	0.0551	0.0522	0.0551
Child-rearing Cost					
$\frac{\tilde{\phi}_U^0 w_S}{\tilde{\phi}_R^0 y_R}$	1.1523	1.1540	1.1506	1.1539	1.1507
$\frac{\tilde{\phi}_U^0 w_P^H}{\tilde{\phi}_R^0 y_R}$	1.3074	1.3093	1.3055	1.3092	1.3056
$\frac{\tilde{\phi}_U^0 w_P^L}{\tilde{\phi}_R^0 y_R}$	0.9376	0.9390	0.9362	0.9389	0.9363
Penalty on Above-quota Birth					
$\frac{(\tilde{\phi}_U+\tilde{\phi}_S)w_S}{(\tilde{\phi}_R+\tilde{\phi}_H)y_R}$	1.1152	1.1310	1.0993	1.1063	1.1261
$\frac{(\tilde{\phi}_U+\tilde{\phi}_P^H)w_P^H}{(\tilde{\phi}_R+\tilde{\phi}_H)y_R}$	0.6323	0.6397	0.6250	0.6309	0.6338
$\frac{\tilde{\phi}_U w_P^L}{\tilde{\phi}_R y_R}$	1.7198	1.7184	1.7212	1.7190	1.7206
$\frac{(\tilde{\phi}_U+\tilde{\phi}_S)w_S}{\tilde{\phi}_R y_R}$	4.8345	4.8264	4.8415	4.8039	4.8694

Table D.2 - continued: Robustness Tests for Model Implications

Calibration	Γ_H	Γ_L	Fraction of H movers	Fraction of L movers	Fraction of movers	$\frac{U^+}{(U^+ + R^+)}$	$\frac{P^{H+}}{P^{L+}}$	$\frac{S^+}{P^{H+}}$	$1-\frac{U}{U^+}$	$\frac{H^+}{L^+}$	$\frac{S^+}{H^+}$
Benchmark	0.0190	0.3576	0.1661	0.0536	0.0646	0.3584	0.6348	3.0262	0.1236	0.0948	3.4836
Robustness Tests											
$\varphi_S = 5\%$, $\varphi_P^H = 22\%$, $\varphi_P^L = 73\%$	0.0346	0.3481	0.1794	0.0522	0.0646	0.3584	0.6493	2.9848	0.1236	0.0932	3.5401
$\varphi_S = 5\%$, $\varphi_P^H = 18\%$, $\varphi_P^L = 77\%$	0.0033	0.3672	0.1528	0.0551	0.0646	0.3584	0.6206	3.0686	0.1236	0.0965	3.4290
$\varphi_S = 7\%$, $\varphi_P^H = 20\%$, $\varphi_P^L = 73\%$	0.0346	0.3481	0.1794	0.0522	0.0646	0.3584	0.6405	3.0400	0.1236	0.0932	3.5563
$\varphi_S = 3\%$, $\varphi_P^H = 20\%$, $\varphi_P^L = 77\%$	0.0033	0.3672	0.1528	0.0551	0.0646	0.3584	0.6293	3.0123	0.1236	0.0965	3.4133

Table D.2 - continued: Robustness Tests for Model Implications

Calibration	Total Fertility Rates								Income Ratios			
	Rural H	Rural$L$	Public	Private$H$	Private$L$	y	y_U	y_R	$\frac{y_U}{y_R}$	$\frac{w_S}{w_P^H}$	$\frac{w_P^H}{w_P^L}$	Urban benefit
Benchmark	1.3858	2.2091	1.1799	1.3456	1.9718	1.3455	1.9641	1.0000	1.9641	0.8814	1.3944	0.9803
Robustness Tests												
$\varphi_S = 5\%$, $\varphi_P^H = 22\%$, $\varphi_P^L = 73\%$	1.3858	2.2091	1.1799	1.3456	1.9718	1.3455	1.9641	1.0000	1.9641	0.8814	1.3944	0.9803
$\varphi_S = 5\%$, $\varphi_P^H = 18\%$, $\varphi_P^L = 77\%$	1.3858	2.2091	1.1799	1.3456	1.9718	1.3455	1.9641	1.0000	1.9641	0.8814	1.3944	0.9803
$\varphi_S = 7\%$, $\varphi_P^H = 20\%$, $\varphi_P^L = 73\%$	1.3858	2.2091	1.1799	1.3456	1.9718	1.3455	1.9641	1.0000	1.9641	0.8814	1.3944	0.9803
$\varphi_S = 3\%$, $\varphi_P^H = 20\%$, $\varphi_P^L = 77\%$	1.3858	2.2091	1.1799	1.3456	1.9718	1.3455	1.9641	1.0000	1.9641	0.8814	1.3944	0.9803

Table D.3: Robustness Tests for Policy Experiments

			Fraction of		Fraction of							Total Fertility Rates								Income Ratios			
	Γ_H	Γ_L	H movers	L movers	movers	$\frac{U^+}{(U^++R^+)}$	$\frac{P^{H+}}{P^{L+}}$	$\frac{S^+}{P^{H+}}$	$1-\frac{U}{U^+}$	$\frac{H^+}{L^+}$	$\frac{S^+}{H^+}$	Rural H	Rural L	Public	Private H	Private L	y	y_U	y_R	$\frac{y_U}{y_R}$	$\frac{w_S}{w_P^H}$	$\frac{w_P^H}{w_P^L}$	Urban benefit
Population Policy																							
Uniform population constraint																							
Benchmark	0.1076	0.3636	0.2415	0.0545	0.0727	0.3640	0.6710	2.8622	0.1370	0.0864	3.8495	1.3321	2.1923	1.1807	1.3544	1.9610	1.3566	1.9673	1.0070	1.9536	0.8856	1.3816	0.9794
(% change)			45.35%	1.68%	12.59%	1.56%	5.69%	-5.42%	10.87%	-8.95%	10.50%	-3.87%	-0.76%	0.06%	0.65%	-0.55%	0.82%	0.17%	0.70%	-0.53%	0.49%	-0.92%	-0.09%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.1181	0.3542	0.2504	0.0531	0.0723	0.3637	0.6840	2.8301	0.1364	0.0852	3.8928	1.3343	2.1931	1.1806	1.3538	1.9614	1.3560	1.9672	1.0067	1.9541	0.8854	1.3824	0.9795
(% change)			39.56%	1.76%	11.96%	1.48%	5.34%	-5.18%	10.33%	-8.56%	9.97%	-3.72%	-0.73%	0.06%	0.61%	-0.53%	0.78%	0.16%	0.67%	-0.51%	0.45%	-0.86%	-0.08%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0983	0.3729	0.2336	0.0559	0.0732	0.3643	0.6585	2.8940	0.1378	0.0874	3.8130	1.3296	2.1912	1.1808	1.3551	1.9605	1.3573	1.9676	1.0075	1.9530	0.8860	1.3807	0.9794
(% change)			52.82%	1.57%	13.36%	1.65%	6.11%	-5.69%	11.52%	-9.45%	11.20%	-4.06%	-0.81%	0.07%	0.70%	-0.58%	0.87%	0.18%	0.75%	-0.57%	0.53%	-0.98%	-0.09%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.1518	0.3529	0.2790	0.0529	0.0749	0.3655	0.6867	2.8480	0.1406	0.0819	4.0835	1.3175	2.1876	1.1812	1.3565	1.9587	1.3596	1.9683	1.0090	1.9508	0.8867	1.3783	0.9793
(% change)			55.53%	1.38%	16.00%	1.98%	7.21%	-6.32%	13.75%	-12.07%	14.83%	-4.93%	-0.98%	0.11%	0.81%	-0.67%	1.04%	0.21%	0.90%	-0.68%	0.61%	-1.15%	-0.09%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0635	0.3732	0.2040	0.0560	0.0704	0.3624	0.6549	2.8856	0.1332	0.0908	3.6409	1.3476	2.1972	1.1803	1.3520	1.9637	1.3534	1.9664	1.0050	1.9566	0.8845	1.3852	0.9796
(% change)			33.46%	1.64%	8.96%	1.11%	4.06%	-4.21%	7.76%	-5.95%	6.67%	-2.75%	-0.54%	0.03%	0.47%	-0.41%	0.58%	0.11%	0.50%	-0.38%	0.35%	-0.66%	-0.07%
No population control																							
Benchmark	0.0000	0.3561	0.1500	0.0534	0.0628	0.3572	0.6272	3.0640	0.1206	0.0967	3.4138	2.7691	2.6981	2.2690	1.9608	2.7597	1.3431	1.9634	0.9985	1.9664	0.8804	1.3972	0.9805
(% change)			-9.71%	-0.42%	-2.74%	-0.34%	-1.21%	1.25%	-2.41%	1.91%	-2.01%	99.82%	22.13%	92.30%	45.72%	39.95%	-0.18%	-0.04%	-0.15%	0.12%	-0.11%	0.20%	0.02%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.0000	0.3451	0.1500	0.0518	0.0613	0.3562	0.6351	3.0545	0.1181	0.0965	3.4111	2.7694	2.7029	2.2680	1.9564	2.7628	1.3411	1.9628	0.9972	1.9683	0.8797	1.3996	0.9806
(% change)			-16.40%	-0.85%	-5.05%	-0.62%	-2.19%	2.33%	-4.45%	3.54%	-3.64%	99.84%	22.35%	92.21%	45.39%	40.11%	-0.33%	-0.07%	-0.28%	0.21%	-0.19%	0.37%	0.04%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0000	0.3669	0.1500	0.0550	0.0643	0.3582	0.6193	3.0752	0.1231	0.0968	3.4168	2.7698	2.6933	2.2697	1.9654	2.7567	1.3451	1.9640	0.9997	1.9645	0.8812	1.3949	0.9803
(% change)			-1.86%	-0.06%	-0.48%	-0.06%	-0.21%	0.21%	-0.42%	0.33%	-0.35%	99.87%	21.92%	92.36%	46.06%	39.80%	-0.03%	-0.01%	-0.03%	0.02%	-0.02%	0.04%	0.00%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.0000	0.3462	0.1500	0.0519	0.0615	0.3563	0.6270	3.1025	0.1183	0.0965	3.4242	2.7940	2.7024	2.2609	1.9589	2.7622	1.3413	1.9628	0.9973	1.9681	0.8797	1.3994	0.9806
(% change)			-16.40%	-0.54%	-4.82%	-0.60%	-2.10%	2.06%	-4.25%	3.55%	-3.71%	101.62%	22.33%	91.61%	45.58%	40.08%	-0.31%	-0.06%	-0.27%	0.20%	-0.19%	0.35%	0.03%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0000	0.3668	0.1500	0.0550	0.0643	0.3582	0.6279	3.0197	0.1230	0.0968	3.4015	2.7410	2.6935	2.2781	1.9626	2.7567	1.3451	1.9640	0.9997	1.9645	0.8812	1.3949	0.9803
(% change)			-1.86%	-0.10%	-0.50%	-0.06%	-0.22%	0.24%	-0.44%	0.33%	-0.35%	97.79%	21.93%	93.07%	45.85%	39.80%	-0.03%	-0.01%	-0.03%	0.02%	-0.02%	0.04%	0.00%

Table D.3 - continued: Robustness Tests for Policy Experiments

			Fraction of		Fraction of							Total Fertility Rates								Income Ratios			Urban
	Γ_H	Γ_L	H movers	L movers	movers	$\frac{U^+}{(U^++R^+)}$	$\frac{P^{H+}}{P^{L+}}$	$\frac{S^+}{P^{H+}}$	$1-\frac{U}{U^+}$	$\frac{H^+}{L^+}$	$\frac{S^+}{H^+}$	Rural H	Rural L	Public	Private H	Private L	y	y_U	y_R	$\frac{y_U}{y_R}$	$\frac{w_S}{w_P^H}$	$\frac{w_P^H}{w_P^L}$	benefit
Migration Policy																							
No urban residency																							
Benchmark	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9342	3.0640	0.0308	0.0915	3.4138	1.4457	2.3011	1.1798	1.4097	1.9773	1.2945	1.9935	0.9593	2.0781	0.9096	1.3075	0.9884
(% change)			-9.71%	-100.00%	-77.43%	-9.57%	47.16%	1.25%	-75.04%	-3.53%	-2.01%	4.32%	4.16%	-0.01%	4.76%	0.28%	-3.79%	1.50%	-4.07%	5.80%	3.21%	-6.24%	0.83%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9364	3.0545	0.0308	0.0915	3.4111	1.4536	2.3015	1.1797	1.4068	1.9786	1.2941	1.9922	0.9593	2.0768	0.9079	1.3119	0.9884
(% change)			-16.40%	-100.00%	-77.43%	-9.57%	44.21%	2.33%	-75.04%	-1.82%	-3.64%	4.89%	4.18%	-0.02%	4.55%	0.34%	-3.83%	1.43%	-4.07%	5.74%	3.01%	-5.92%	0.83%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9317	3.0752	0.0308	0.0915	3.4168	1.4381	2.3007	1.1799	1.4126	1.9762	1.2949	1.9947	0.9593	2.0794	0.9113	1.3031	0.9884
(% change)			-1.86%	-100.00%	-77.43%	-9.57%	50.12%	0.21%	-75.04%	-5.19%	-0.35%	3.77%	4.15%	0.00%	4.98%	0.22%	-3.77%	1.56%	-4.07%	5.87%	3.40%	-6.55%	0.83%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9255	3.1025	0.0308	0.0915	3.4242	1.4536	2.3015	1.1795	1.4059	1.9787	1.2941	1.9923	0.9593	2.0768	0.9083	1.3114	0.9882
(% change)			-16.40%	-100.00%	-77.43%	-9.57%	44.50%	2.06%	-75.04%	-1.82%	-3.71%	4.90%	4.18%	-0.03%	4.48%	0.35%	-3.82%	1.43%	-4.07%	5.74%	3.05%	-5.95%	0.81%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9445	3.0197	0.0308	0.0915	3.4015	1.4368	2.3007	1.1799	1.4140	1.9757	1.2949	1.9947	0.9593	2.0794	0.9111	1.3032	0.9886
(% change)			-1.86%	-100.00%	-77.43%	-9.57%	50.09%	0.24%	-75.04%	-5.19%	-0.35%	3.68%	4.15%	0.00%	5.08%	0.20%	-3.76%	1.56%	-4.07%	5.87%	3.37%	-6.54%	0.85%
No urban benefits																							
Benchmark	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9342	3.0640	0.0308	0.0915	3.4138	1.4605	2.3011	1.1798	1.3933	1.9773	1.2945	1.9935	0.9593	2.0781	0.9096	1.3075	0.9870
(% change)			-9.71%	-100.00%	-77.43%	-9.57%	47.16%	1.25%	-75.04%	-3.53%	-2.01%	5.39%	4.16%	-0.01%	3.54%	0.28%	-3.79%	1.50%	-4.07%	5.80%	3.21%	-6.24%	0.69%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9364	3.0545	0.0308	0.0915	3.4111	1.4688	2.3015	1.1797	1.3901	1.9786	1.2941	1.9922	0.9593	2.0768	0.9079	1.3119	0.9871
(% change)			-16.40%	-100.00%	-77.43%	-9.57%	44.21%	2.33%	-75.04%	-1.82%	-3.64%	5.99%	4.18%	-0.02%	3.31%	0.34%	-3.83%	1.43%	-4.07%	5.74%	3.01%	-5.92%	0.69%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9317	3.0752	0.0308	0.0915	3.4168	1.4526	2.3007	1.1799	1.3965	1.9762	1.2949	1.9947	0.9593	2.0794	0.9113	1.3031	0.9870
(% change)			-1.86%	-100.00%	-77.43%	-9.57%	50.12%	0.21%	-75.04%	-5.19%	-0.35%	4.82%	4.15%	0.00%	3.78%	0.22%	-3.77%	1.56%	-4.07%	5.87%	3.40%	-6.55%	0.69%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9255	3.1025	0.0308	0.0915	3.4242	1.4676	2.3015	1.1795	1.3907	1.9787	1.2941	1.9923	0.9593	2.0768	0.9083	1.3114	0.9869
(% change)			-16.40%	-100.00%	-77.43%	-9.57%	44.50%	2.06%	-75.04%	-1.82%	-3.71%	5.91%	4.18%	-0.03%	3.35%	0.35%	-3.82%	1.43%	-4.07%	5.74%	3.05%	-5.95%	0.68%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0000	0.0000	0.1500	0.0000	0.0146	0.3241	0.9445	3.0197	0.0308	0.0915	3.4015	1.4527	2.3007	1.1799	1.3961	1.9757	1.2949	1.9947	0.9593	2.0794	0.9111	1.3032	0.9871
(% change)			-1.86%	-100.00%	-77.43%	-9.57%	50.09%	0.24%	-75.04%	-5.19%	-0.35%	4.83%	4.15%	0.00%	3.75%	0.20%	-3.76%	1.56%	-4.07%	5.87%	3.37%	-6.54%	0.70%
Full urban benefits																							
Benchmark	0.0000	1.0000	0.1500	0.1500	0.1500	0.4170	0.3934	3.0640	0.2467	0.1076	3.4138	1.2812	2.0551	1.1798	1.2780	1.9188	1.4278	1.9132	1.0806	1.7705	0.8416	1.5102	0.9713
(% change)			-9.71%	179.62%	132.29%	16.35%	-38.03%	1.25%	99.65%	13.49%	-2.01%	-7.55%	-6.97%	-0.01%	-5.03%	-2.69%	6.12%	-2.59%	8.06%	-9.86%	-4.52%	8.30%	-0.91%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.0000	1.0000	0.1500	0.1500	0.1500	0.4170	0.3943	3.0545	0.2467	0.1076	3.4111	1.2885	2.0554	1.1797	1.2753	1.9206	1.4271	1.9114	1.0806	1.7687	0.8402	1.5153	0.9713
(% change)			-16.40%	187.28%	132.29%	16.35%	-39.27%	2.33%	99.65%	15.50%	-3.64%	-7.02%	-6.96%	-0.02%	-5.22%	-2.60%	6.06%	-2.68%	8.06%	-9.95%	-4.67%	8.67%	-0.92%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0000	1.0000	0.1500	0.1500	0.1500	0.4170	0.3923	3.0752	0.2467	0.1076	3.4168	1.2742	2.0547	1.1799	1.2806	1.9171	1.4286	1.9151	1.0806	1.7721	0.8430	1.5052	0.9714
(% change)			-1.86%	172.35%	132.29%	16.35%	-36.78%	0.21%	99.65%	11.54%	-0.35%	-8.06%	-6.99%	0.00%	-4.83%	-2.77%	6.17%	-2.50%	8.06%	-9.77%	-4.36%	7.94%	-0.91%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.0000	1.0000	0.1500	0.1500	0.1500	0.4170	0.3897	3.1025	0.2467	0.1076	3.4242	1.2872	2.0554	1.1795	1.2753	1.9197	1.4272	1.9116	1.0806	1.7690	0.8401	1.5148	0.9714
(% change)			-16.40%	187.28%	132.29%	16.35%	-39.15%	2.06%	99.65%	15.50%	-3.71%	-7.11%	-6.96%	-0.03%	-5.23%	-2.64%	6.07%	-2.67%	8.06%	-9.94%	-4.68%	8.63%	-0.91%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0000	1.0000	0.1500	0.1500	0.1500	0.4170	0.3977	3.0197	0.2467	0.1076	3.4015	1.2744	2.0547	1.1799	1.2809	1.9177	1.4285	1.9149	1.0806	1.7720	0.8432	1.5052	0.9713
(% change)			-1.86%	172.35%	132.29%	16.35%	-36.80%	0.24%	99.65%	11.54%	-0.35%	-8.04%	-6.99%	0.00%	-4.81%	-2.74%	6.17%	-2.50%	8.06%	-9.78%	-4.33%	7.95%	-0.92%

Table D.3 - continued: Robustness Tests for Policy Experiments

	Γ_H	Γ_L	Fraction of H movers	Fraction of L movers	Fraction of movers	$\frac{U^+}{(U^++R^+)}$	$\frac{P^{H+}}{P^{L+}}$	$\frac{S^+}{P^{H+}}$	$1-\frac{U}{U^+}$	$\frac{H^+}{L^+}$	$\frac{S^+}{H^+}$	Total Fertility Rates: Rural H	Rural L	Public	Private H	Private L	y	y_U	y_R	Income Ratios: $\frac{y_U}{y_R}$	$\frac{w_S}{w_P^H}$	$\frac{w_P^H}{w_P^L}$	Urban benefit
Land Policy																							
Immediate loss of land entitlement																							
Benchmark	0.0000	0.3078	0.1500	0.0462	0.0563	0.3527	0.6565	3.0640	0.1094	0.0959	3.4138	1.3881	2.1960	1.1798	1.3497	1.9765	1.3442	1.9674	1.0047	1.9582	0.8840	1.3867	0.9812
(% change)			-9.71%	-13.94%	-12.88%	-1.59%	3.41%	1.25%	-11.47%	1.14%	-2.01%	0.17%	-0.59%	-0.01%	0.30%	0.24%	-0.10%	0.17%	0.47%	-0.30%	0.29%	-0.56%	0.10%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.0000	0.2983	0.1500	0.0447	0.0550	0.3518	0.6641	3.0545	0.1072	0.0958	3.4111	1.3981	2.1994	1.1797	1.3479	1.9784	1.3423	1.9668	1.0033	1.9602	0.8831	1.3892	0.9814
(% change)			-16.40%	-14.31%	-14.88%	-1.84%	2.28%	2.33%	-13.28%	2.77%	-3.64%	0.89%	-0.44%	-0.02%	0.17%	0.33%	-0.24%	0.14%	0.33%	-0.20%	0.20%	-0.37%	0.12%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0000	0.3171	0.1500	0.0476	0.0575	0.3536	0.6488	3.0752	0.1116	0.0961	3.4168	1.3785	2.1928	1.1799	1.3515	1.9747	1.3462	1.9681	1.0060	1.9563	0.8848	1.3841	0.9811
(% change)			-1.86%	-13.63%	-10.92%	-1.35%	4.55%	0.21%	-9.71%	-0.46%	-0.35%	-0.52%	-0.74%	0.00%	0.43%	0.15%	0.05%	0.20%	0.60%	-0.40%	0.39%	-0.74%	0.08%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.0000	0.2991	0.1500	0.0449	0.0551	0.3519	0.6558	3.1025	0.1074	0.0958	3.4242	1.3967	2.1991	1.1795	1.3482	1.9781	1.3424	1.9668	1.0035	1.9600	0.8832	1.3889	0.9813
(% change)			-16.40%	-14.08%	-14.71%	-1.82%	2.40%	2.06%	-13.13%	2.79%	-3.71%	0.79%	-0.45%	-0.03%	0.19%	0.32%	-0.23%	0.14%	0.35%	-0.21%	0.21%	-0.39%	0.11%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0000	0.3172	0.1500	0.0476	0.0575	0.3536	0.6577	3.0197	0.1116	0.0961	3.4015	1.3787	2.1927	1.1799	1.3514	1.9747	1.3462	1.9681	1.0061	1.9562	0.8848	1.3842	0.9811
(% change)			-1.86%	-13.62%	-10.91%	-1.35%	4.52%	0.24%	-9.69%	-0.46%	-0.35%	-0.51%	-0.74%	0.00%	0.43%	0.15%	0.05%	0.20%	0.61%	-0.40%	0.39%	-0.73%	0.09%
15 years of guaranteed land tenure																							
Benchmark	0.1094	0.4377	0.2430	0.0656	0.0829	0.3710	0.6291	2.8590	0.1533	0.0872	3.8578	1.3428	2.2163	1.1807	1.3460	1.9568	1.3555	1.9615	0.9982	1.9651	0.8807	1.3965	0.9782
(% change)			46.28%	22.38%	28.35%	3.50%	-0.90%	-5.52%	24.01%	-8.05%	10.74%	-3.10%	0.32%	0.07%	0.03%	-0.76%	0.74%	-0.13%	-0.18%	0.05%	-0.08%	0.15%	-0.21%
$\varphi_S=5\%$, $\varphi_P^H=22\%$, $\varphi_P^L=73\%$	0.1263	0.4280	0.2573	0.0642	0.0830	0.3710	0.6439	2.8160	0.1534	0.0854	3.9309	1.3409	2.2161	1.1807	1.3461	1.9567	1.3556	1.9616	0.9982	1.9651	0.8807	1.3964	0.9782
(% change)			43.43%	22.95%	28.48%	3.52%	-0.84%	-5.66%	24.11%	-8.34%	11.04%	-3.24%	0.32%	0.06%	0.04%	-0.77%	0.75%	-0.13%	-0.18%	0.05%	-0.07%	0.14%	-0.22%
$\varphi_S=5\%$, $\varphi_P^H=18\%$, $\varphi_P^L=77\%$	0.0926	0.4472	0.2287	0.0671	0.0828	0.3709	0.6146	2.9039	0.1531	0.0890	3.7877	1.3447	2.2165	1.1808	1.3458	1.9569	1.3554	1.9614	0.9981	1.9652	0.8806	1.3967	0.9782
(% change)			49.65%	21.80%	28.20%	3.49%	-0.97%	-5.37%	23.89%	-7.79%	10.46%	-2.96%	0.33%	0.07%	0.01%	-0.76%	0.73%	-0.14%	-0.19%	0.05%	-0.09%	0.16%	-0.21%
$\varphi_S=7\%$, $\varphi_P^H=20\%$, $\varphi_P^L=73\%$	0.1253	0.4251	0.2565	0.0638	0.0825	0.3707	0.6332	2.8890	0.1526	0.0855	3.9517	1.3448	2.2168	1.1809	1.3455	1.9578	1.3551	1.9615	0.9979	1.9656	0.8805	1.3971	0.9783
(% change)			42.94%	22.11%	27.74%	3.43%	-1.13%	-4.97%	23.50%	-8.27%	11.12%	-2.96%	0.35%	0.09%	-0.01%	-0.71%	0.71%	-0.13%	-0.21%	0.08%	-0.10%	0.19%	-0.20%
$\varphi_S=3\%$, $\varphi_P^H=20\%$, $\varphi_P^L=77\%$	0.0939	0.4508	0.2298	0.0676	0.0834	0.3713	0.6255	2.8257	0.1540	0.0889	3.7676	1.3402	2.2156	1.1804	1.3465	1.9556	1.3561	1.9615	0.9985	1.9645	0.8809	1.3959	0.9778
(% change)			50.38%	22.76%	29.12%	3.60%	-0.61%	-6.20%	24.63%	-7.87%	10.38%	-3.29%	0.29%	0.04%	0.06%	-0.82%	0.78%	-0.13%	-0.15%	0.02%	-0.05%	0.10%	-0.25%