Educational Choice, Rural-urban Migration and Economic Development: The Role of *Zhaosheng* in China

Pei-Ju Liao[a], Ping Wang[b], Yin-Chi Wang[c,*], Chong Kee Yip[d]

[a]Institute of Economics, Academia Sinica, Taipei, Taiwan
[b]Department of Economics, Washington University in St. Louis, St. Louis, USA & NBER, USA
[c]Chinese University of Hong Kong, Hong Kong SAR
[d]Chinese University of Hong Kong, Hong Kong SAR

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Abstract: Observing China's rapid skill-enhanced development and urbanization process accompanied by continual reforms of the household registration system, we explore the underlying drivers, highlighting the channel of rural to urban migration. In addition to conventional work-based migration, we incorporate education-based migration by constructing a dynamic spatial equilibrium model of migration decisions with educational choice. We then calibrate our model to fit the data from China over the 1980–2007 period. We find that the effects of education-based migration on total per capita output cannot be ignored. There also exist rich interactions between the two migration channels. Furthermore, our results suggest that the increase in the college admission selectivity for rural students seriously depresses China's development. Policy experiments on migration and labour-market regulations are also conducted to assess their quantitative significance.

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*Corresponding author. E-mail: ycwang@cuhk.edu.hk. Fax: (852)2603 5805. E-mail addresses: pjliao@econ.sinica.edu.tw (P.-J. Liao), pingwang@wustl.edu (P. Wang), chongkeeyip@cuhk.edu.hk (C. K. Yip). Acknowledgements: We are grateful for comments from the participants at the Washington University in St. Louis Macro reading group, Asian Meeting of the Econometric Society, SAET Conference on Current Trends in Economics, IEAS and CCER joint workshop, the seminars at the IEAS, National Graduate Institute for Policy Studies (GRIPS) and National Taiwan University, Chinese University of Hong Kong lunch meeting group, Conference on Chinese Economy at Tsinghua University, CUHK Symposium on Growth and Development, annual conference of the Asian Bureau of Finance and Economic Research (ABFER), and PET conference 2015. Travel support from the Chinese University of Hong Kong, Tsinghua University, Center for Dynamic Economics at Washington University, and the Ministry of Science and Technology of Taiwan are greatly appreciated. We wish to express special thanks to B. Ravikumar for his comments at the early stage of this project and to Suqin Ge and Dennis Tao Yang for providing the data on the skill premium in China. All remaining errors are our own.

1 Introduction

Over the past three decades, we have observed rapid economic growth and urbanization in China. Real per capita GDP over our sample period of 1980 to 2007 has grown at an annual rate of approximately 6.0 per cent, whereas the comparable figure since Deng Xiao-Ping's Southern Trip in 1992 is 7.6 per cent. A special feature of China's development experience is its continual reform of the household registration system, *hukou*, which has been a severe barrier to rural to urban migration.[1] Over the same sample period, as shown in Figure 1(a), urbanization rates (urban population shares) and urban output shares have increased from 19.4 to 44.9 per cent and from 66.7 to 87.3 per cent, respectively. Even more drastic, as shown in Figure 1(b), the migration flows (proxied by changes in urban population) over rural population have nearly quadrupled, increasing from 0.5 to 1.9 per cent, and urban tertiary education employment shares have increased seven-fold from 2.2 to 15.4 per cent.[2]

The above figures illustrate the close relations among these urban variables.[3] While conventional rural to urban migration emphasizes work-based migration (*zhaogong*, *zhaogan* and *nongmingong*),[4] these observations highlight an important message that skill development and education should not be ignored in the analysis. The following question naturally arises: what are the underlying drivers of this marked skill-enhanced development and urbanization process? In this paper, we focus on a potentially important channel of rural to urban migration – higher education, which is referred to as *zhaosheng*. Unlike other countries, *zhaosheng* is a unique and specific channel that mitigates migration barriers in China. Specifically, students attend college by passing the National College Entrance Examination, *gaokao,* and migrating to cities. Before 1994, all college graduates were assigned jobs by the government before graduation (hereafter, *government job assignment,* GJA)

[1] Under the *hukou* registration system that started in the 1950s, it is difficult for migrants to obtain an urban *hukou.* Unlike other countries, the Chinese government used *hukou* registration to conduct social planning, including job opportunities, children's education, and other benefits.

[2] The sizeable drop in the N_H/N_U rate of change shown in Figure 1(b) can be attributed to the rezoning of metropolitan areas.

[3] We note that the data for urban tertiary education employment shares are usually very noisy, especially when there is rezoning. For the other three variables, the correlations range from 0.71 to 0.96. In addition, if we ignore the rezoning year (2005) for the urban tertiary education employment shares, then its correlations with the other three variables increase from the range of 0.068–0.24 to 0.41–0.52.

[4] *Zhaogong* and *zhaogan* are mostly to state-owned enterprises, while *nongmingong* is usually to the private sector. We will provide more institutional details in Section 2 and Appendix A.

and could officially obtain an urban *hukou.* In 1995, the GJA policy was abolished, and jobs are no longer guaranteed. Thus, the termination of GJA and migration regulations create two natural policy experiments that can be used to evaluate their roles in China's development process.

In this paper, we construct a dynamic equilibrium model that includes intergenerational migration decisions based on education. It allows human capital accumulation and intergenerational mobility to explore both work- and education-based rural to urban migration. Since college education for children is a huge investment calling for full support by parents, it is natural to lay the framework in a two-period overlapping generations model with altruistic parents making crucial education-migration decisions for their children. We calibrate the model to Chinese data for our sample period (1980–2007) and then perform a quantitative analysis to investigate the influences of both types of migration on development and urbanization. We further decompose the effects of various factors guided by the model parameters. Finally, we conduct policy experiments to the influence of the GJA policy and labour-market regulations.

The main findings of our paper are summarized as follows. First, the contribution of education-based migration is larger than that of work-based migration, accounting for 6.3 and 4.5 per cent, respectively, of changes in per capita output during the sample period. Interestingly, in the sub-sample period of 1995–2007, we obtain a similar pattern for the comparable contributions of education- and work-based migration (8.0 and 5.9 per cent, respectively). This is in contrast with the survey information on migration by reasons (Table 1) where on average education-based migration only amounts to one-fifth of that of work-based migration. These findings suggest that without examining the education channel, we could obtain a very misleading picture of rural to urban migration in China. Second, there are rich interactions between education- and work-based migration in our dynamic general equilibrium setting. It is intuitive that the interactive effect is strongest for the high-skilled employment share (accounting for 11 per cent of its change over the entire sample period). Such interactions in terms of total output per capita are also positive but small (accounting for 0.1 per cent of its change over the entire sample period) because of several conflicting forces in the model, with the effects of the skill premium and intergenerational mobility dominating. Third, the results of factor decomposition suggest that the increase in admission selectivity for rural children play a crucial but negative role in China's development in 1994-2007. Finally, the policy experiments suggest that it is not excessively harmful if China had not introduced the GJA policy throughout the history. Total per capita output would have decreased by 1.2 percentage and urban employment share dropped by 0.4 percent.

Related Literature

Research on rural-urban migration was pioneered by Todaro (1969) and Harris and Todaro (1970). Since then, researchers have attempted to understand the forces driving rural to urban migration as well as the impacts of such migration on the development process, income inequality across regions, and problems that arise from urbanization. Glomm (1992) developed a dynamic general equilibrium model with persistent urbanization along the equilibrium path. Observing that rural workers are moving to cities despite the fact that they may end up unemployed or living in shanty towns, Lucas (2004) suggested that cities attract migrant workers not only because of the better job opportunities but also because the accumulation and spillover of human capital in cities can benefit rural migrants.

The *hukou* system and strictly controlled population movement have made the urbanization process in China different from that in other developing countries. It is believed that the *hukou* system maintained a labour force in rural areas and prevented shanty towns from emerging, resulting in relatively low labour costs compared to other countries. As China expanded its participation in world trade, the sizeable cheap labour force from rural areas served as the main driving force of its growth.

Previous research on rural to urban migration in China has usually adopted the reduced-form empirical approach. Those studies investigate issues such as the happiness of migrant workers and the factors that either push rural workers away from or keep them in their hometowns. Most of these, as the authors are aware, focus on work-based migration. Although a few studies explore education and migration, they typically examine topics such as the academic performance of rural children who are left behind, whether education imparts to rural workers greater ability to migrate to cities or increases the chance of obtaining an urban *hukou*, and the inequality of educational opportunities for migrant children in cities. As we adopt a more structural approach to address the channel of China's education-based migration, which has not yet been explored in the literature, below we discuss only studies that are more model oriented.

Of the theoretical and calibration work examining rural to urban migration in China, Bond, Riezman and Wang (2015) studied the effects of reductions in trade and migration barriers on China's growth and urbanization, focusing on China's accession to the World Trade Organization in 2002. Garriga, Tang and Wang (2014) studied the structural transformation and the consequent reallocation of labour from rural to urban areas in China. They found that two-thirds of the increases in land and housing prices can be attributed to the urbanization and development processes. Tombe and Zhu (2015) study the effects of opening the domestic market to international trade on migration and regional income differences in China. Other studies adopt computable general equilibrium frameworks or numerical simulation methods to investigate the relationship between migration barriers and rural to urban income inequality in China. These studies usually consider static settings, and the approaches employed are very different from ours. We develop a dynamic macroeconomic model to address the causes and consequences of migration on the development of China.

The remainder of this paper is organized as follows. Section 2 provides a brief introduction to the institutional background of the education-based migration in China. Section 3 presents the model and conducts the theoretical analysis. The calibration strategy, simulation, decomposition analysis on education- and work-based migration as well as the policy experiments are given in Section 4. Finally, Section 5 concludes the paper.

2 Institutional Background of *Zhaosheng*

Our theoretical framework in Section 3 is residence-based rather than *hukou*-based. However, the important role of *zhaosheng* in China's development is indeed due to the *hukou* regulation. Therefore, in this section we briefly review the institutional background of the *hukou* system and *zhaosheng*, which is one of the regular channels for obtaining a formal urban *hukou* under China's strict *hukou* regulation. The details of the *hukou* system and its reform are relegated to Appendix A.

China implemented the *hukou* system in 1958 to solve the serious problem of "blind flows" (of rural workers into cities) in the early 1950s. The *hukou* system not only regulated internal population movement but also governed the social and economic aspects of a citizen's life. In rural areas, which were organized through the commune system, all rural residents had to participate in agricultural production to receive food rations for their households. In urban areas, under the pre-reform regime, the government essentially controlled job assignments, grain rations, education for children, health benefits, and housing purchase rights. Thus, during the pre-reform period, people were not able to survive outside of their *hukou* registration area. A series of economic reforms began in the late 1970s. Since then, the increasingly market-oriented economy, the rural-urban income gap and the demand for cheap labour from rural areas have greatly increased informal rural-urban migrants, which has led to the continual relaxation of the *hukou* system. The ultimate aim of

China's *hukou* reform is to abolish the regulation of migration through the *hukou* system.

Although the system has been gradually relaxed, especially after 1990, it still formed the basis of China's registration system over the last decade. The annual quota for rural people obtaining a formal urban *hukou* was tightly controlled by the central government at approximately 0.15–0.2 per cent of the population in each area. The regular channels for obtaining formal urban *hukou* included (i) recruitment by a state-owned enterprise (*zhaogong*), (ii) promotion to a senior administrative job (*zhaogan*) and (iii) enrolment in an institution of higher education (*zhaosheng*). Table 1 summarizes the number of migrants and their reasons for migration in 1985 and 2000.[5] In 1985, migration due to a job transfer or job assignment accounted for more than one-third of total migrants, while the percentage migrating due to studying or training ranged between 7 and 11 per cent.

Because *zhaosheng* was an important channel for rural people, especially for rural youths, to obtain formal urban *hukou* in China, we shift our focus to the tertiary education system and to the procedure in which rural students could obtain formal urban *hukou* through *zhaosheng*. As mentioned in Section 1, students in China must pass *gaokao* to be admitted to universities. The *gaokao* system was established at the beginning of the 1950s, abolished during the Cultural Revolution, and restored in 1977. Because of the scarcity of education resources, acceptance rates were very low, especially in the 1980s. As most universities and colleges in China were located in urban areas, they were considered urban collective units. Once a rural student was admitted to a university or a college, upon starting his freshman year, the student could voluntarily move his *hukou* to the school and obtain an urban *hukou*. However, such urban *hukou* was *temporary*. The youth's *hukou* would be removed from the school after graduation and moved to his work unit if he successfully found a job; otherwise, he was required to move his *hukou* back to his hometown. During the years of the GJA policy (1951–1994), a college graduate was assigned a stable government job, usually in an urban work unit. His *hukou* was thus transferred to the urban work unit immediately after graduation, allowing him to keep an urban *hukou* henceforth. However, after the termination of the GJA policy, college graduates were no longer guaranteed a governmental job.[6] If a college graduate fails to find an urban job upon graduation, he can temporarily assign his *hukou* to the

[5] The survey of reasons for migration is by residence and not by *hukou*. As long as the survey subject was responding to the questionnaires, he or she was included in the survey, regardless of whether the subject was residing in his or her *hukou* registration place.

[6] The reform of the GJA policy started in 1989, but it was officially ended in 1996. Tibet, which abolished the system in 2007, was the last place to terminate the distribution system of graduation.

collective joint household of a personal exchange center if he is still searching for an urban job or move his *hukou* back to his hometown. Therefore, under China's *hukou* system, entering college through the *gaokao* provides a formal channel for rural-urban migration, and it provides rural youths with greater upward mobility in society.

Since 1996, China has introduced a series of education reforms, especially the college education expansion and increases in college tuition. The expansion policy has provided broader access to students from lower income families and reduced the rural-urban disparity. However, as discussed in the literature, because of the increase in college tuition, lower income families shoulder a much higher burden for children' college education. Thus, the disparity between rural and urban areas still exists, in particular the opportunities to attend top universities. To consider the effects of the two educational reforms on rural-urban migration, the main spirits of the two reforms are captured in our quantitative analysis.[7]

3 The Model

In this section, we develop a discrete choice model of rural-urban migration. Instead of distinguishing *hukou* and *non-hukou* holders, our model is residence-based. We apply the model to study the transition process of rural-urban migration and to evaluate the policies that govern it. We use (i, j, k) to denote three consecutive generations and let (H, L) denote high and low skills, respectively. There are two geographical regions, rural (R) and urban (U). Our optimization problem focuses only on the decision of rural parents (generation i) to send their children to urban areas to have their education. Assume that there is an initial mass of workers in urban area given by (N_H, N_L), where N_H (N_L) denotes the total number of workers with high (low) skills. To focus on rural-urban migration, the endogenous decision to "move back" from urban to rural areas is ignored, and the *residences* of urban households are assumed to pass from one generation to another. To simplify the analysis, we assume zero population growth so that the total population in rural and urban areas is constant over time.

[7] See, for example, Li (2007) and Qiao (2010).

3.1 Production

In urban areas, output is produced from the following non-homothetic CES production function:

$$Y_U = AF\left\{(N_H + \psi)\, h, N_L\right\}, \tag{1}$$

where $A > 0$ is the technology scaling factor in urban areas (also called the urban TFP; hereafter, we will use these two terms interchangeably), ψ is a constant endowment that resides in urban areas, and h is the level of human capital possessed by high-skilled workers. The outcome of education is the acquisition of h, which is assumed to be a constant level.[8] The presence of ψ allows firms to produce positive output even if there are no high-skilled workers.

As documented by Maurer-Fazio (1999), the skilled labour wage in China was depressed by the planned economy system. To capture this distortion, we introduce a distortionary wedge $\tau \in (-1, \infty)$ faced by urban firms when hiring high-skilled workers. Denoting w_H as the effective high-skilled wage received by high-skilled workers and w_L as the low-skilled wage, we obtain the urban wage rates as follows:

$$(1+\tau)\, w_H = \frac{\partial Y_U}{\partial\left[(N_H + \psi)\, h\right]} = AF_H, \tag{2}$$

$$w_L = \frac{\partial Y_U}{\partial N_L} = AF_L, \tag{3}$$

where $F_H = \partial F / \partial\left[(N_H + \psi)\, h\right]$ and $F_L = \partial F / \partial N_L$. Then, the skilled-unskilled wage ratio is:

$$\frac{w_H h}{w_L} = \frac{h}{1+\tau} \frac{F_H}{F_L}. \tag{4}$$

Rural production uses only raw (or unskilled) labour, and constant returns requires a linear production technology:

$$Y_R = BN_R, \tag{5}$$

where N_R is the number of raw labourers in the rural area and B is the technology scaling factor in the rural area. A competitive labour market implies that the rural wage rate is:

$$w_R = B. \tag{6}$$

[8] We can think of h as an index on labour quality or human capital that results from the total number of years in higher education.

3.2 Rural households

Rural households (generation i) are altruistic and derive utility from both their own consumption (c^i) and their children's consumption (c^j). There is no fertility decision, and we assume that each adult agent gives birth to a child. Assuming the utility function $u(\cdot)$ is strictly increasing and strictly concave, the representative household's objective is:

$$\Omega^i\left(\mathbf{I}^j|\mathbf{I}^i=0,\mathbf{I}^k,x^j\right)=\max_{\mathbf{I}^j} u\left(c^i\right)+\beta\mathbb{E}_{\mathrm{X}}u\left(c^j\right), \tag{7}$$

where β is the altruistic factor on children, and $\mathbf{I}^j$ is an indicator function of migration such that[9]

$$\mathbf{I}^j=\begin{cases}0 & if \text{ the household does not send generation } j \text{ (children) to college in an urban area}\\ 1 & if \text{ the household sends generation } j \text{ (children) to college in an urban area.}\end{cases}$$

There are two types of costs in raising children. First, there is a basic requirement for resources, which we assume to be a constant child-rearing cost, denoted by ϕ^i. Second, there are costs to improve the child's quality, which we can summarize as education costs. Since talent matters for education because people who are more talented study more efficiently, we assume that part of the education costs depend on the talent of the child. Specifically, we denote the education cost as x^j, which is a random variable that consists of two parts; one part is inversely related to the talents of the child z^j and the college admission selectivity a, whereas another part is a constant for basic expenses b:

$$x^j\equiv\frac{1}{az^j}+b. \tag{8}$$

We note that z^j is drawn from a distribution with cumulative distribution function denoted by $G\left(z^j\right)$. Finally, as the education of children takes place only in urban areas, there is a constant migration cost denoted by σ which captures the basic moving expenses.[10] Thus, the budget constraint for a rural parent is:

$$c^i+\mathbf{I}^j\cdot\left(x^j+\sigma\right)+\phi^i=w_R. \tag{9}$$

[9] This paper ignores the possibility of parents sending children to rural colleges because most tertiary schools in China are located in cities. According to the data from the Chinese Ministry of Education, up to 2015, there are 2553 junior colleges, colleges and universities in China, and only 12 of them (0.47%) are located in county-level cities. The rest (99.53%) are located in prefectural-level cities or municipalities.

[10] Our migration costs can be interpreted as the costs of obtaining the legal right to stay in cities, transportation costs between hometowns and cities and urban living costs. In the quantitative analysis, we distinguish the education-based migration cost from the work-based migration cost .

Children who are sent to urban areas become skilled workers after receiving their education. They can obtain jobs that need high (low) skills in urban areas, earning a wage w_H (w_L) with probability γ_H (γ_L); otherwise, they are forced to move back to rural areas, earning a rural wage w_R. Children that remain in the rural area do not incur any cost in education or migration for their parents. When these children turn adults, they either get recruited as low-skilled workers in urban areas and earn w_L (with probability π) or work as unskilled labourers in a rural area and earn w_R. Their income (generation j) in the adulthood is given by:

$$W^j = \mathbf{I}^j \left[\gamma_H w_H h + \gamma_L w_L + (1 - \gamma_H - \gamma_L) w_R\right] + \left(1 - \mathbf{I}^j\right) \left[(1 - \pi) w_R + \pi (w_L - \sigma)\right]. \tag{10}$$

Then, the children's budget constraint is given by:

$$c^j + \mathbf{I}^k \cdot \left[\mathbf{I}^j (1 - \gamma_H - \gamma_L) + \left(1 - \mathbf{I}^j\right)(1 - \pi)\right] \left(x^k + \sigma\right) + \phi^j = W^j, \tag{11}$$

where

$$\mathbf{I}^k = \begin{cases} 0 & if \text{ children do not send generation } k \text{ (grandchildren) to college in an urban area} \\ 1 & if \text{ children send generation } k \text{ (grandchildren) to college in an urban area} \end{cases}$$

and x^k is the education cost of grandchildren going to college in cities. When households of generation i decide $\mathbf{I}^j$, x^k is unknown. We use X to denote the random variable of education cost in their value function Ω^i. For illustration purposes, we plot the timeline of the model in Figure 2.

An agent's discrete choice problem is to decide whether to send his or her child to an urban area to attend college ($\mathbf{I}^j = 1$ versus $\mathbf{I}^j = 0$). That is, the agent compares $\Omega^i\left(1|0, \mathbf{I}^k, x^j\right)$ to $\Omega^i\left(0|0, \mathbf{I}^k, x^j\right)$ and chooses the highest value between the two. By substituting $c^i = w_R - \mathbf{I}^j \cdot \left(x^j + \sigma\right) - \phi^i$ and $c^j = W^j - \mathbf{I}^k \cdot \left[\mathbf{I}^j (1 - \gamma_H - \gamma_L) + \left(1 - \mathbf{I}^j\right)(1 - \pi)\right]\left(x^k + \sigma\right) - \phi^j$ into the value functions, where W^j is given by (10), we have:

$$\begin{aligned} \Omega^i\left(1|0, \mathbf{I}^k, x^j\right) &= u\left(w_R - x^j - \sigma - \phi^i\right) \\ &\quad + \beta \mathbb{E}_{\mathrm{X}} u \begin{pmatrix} \gamma_H w_H h + \gamma_L w_L + (1 - \gamma_H - \gamma_L) w_R \\ -\mathbf{I}^k (X)(1 - \gamma_H - \gamma_L)(X + \sigma) - \phi^j \end{pmatrix} \end{aligned}$$

and

$$\Omega^i\left(0|0, \mathbf{I}^k, x^j\right) = u\left(w_R - \phi^i\right) + \beta \mathbb{E}_{\mathrm{X}} u \left[(1 - \pi) w_R + \pi (w_L - \sigma) - \mathbf{I}^k (X)(1 - \pi)(X + \sigma) - \phi^j\right].$$

Defining the net gain in value for sending children to urban areas to continue their educations as $\Delta^i\left(\mathbf{I}^k, x^j\right) \equiv \Omega^i\left(1|0, \mathbf{I}^k, x^j\right) - \Omega^i\left(0|0, \mathbf{I}^k, x^j\right)$, we obtain:

$$\begin{aligned} \Delta^i\left(\mathbf{I}^k, x^j\right) &= u\left(w_R - x^j - \sigma - \phi^i\right) - u\left(w_R - \phi^i\right) \\ &+\beta\mathbb{E}_{\mathrm{X}}\left\{\begin{array}{c} u\left(\gamma_H w_H h + \gamma_L w_L + (1\text{-}\gamma_H\text{-}\gamma_L)\, w_R\text{-}\mathbf{I}^k(X)\,(1\text{-}\gamma_H\text{-}\gamma_L)\,(X+\sigma)\text{-}\phi^j\right) \\ \text{-}u\left((1\text{-}\pi)\, w_R + \pi\,(w_L\text{-}\sigma)\,\text{-}\mathbf{I}^k(X)\,(1-\pi)\,(X+\sigma)\text{-}\phi^j\right) \end{array}\right\}. \end{aligned} \tag{12}$$

Further, we define $n \equiv (N_H + \psi)h/N_L$ to be the high-skilled to low-skilled labour ratio. Then, the high-skilled and low-skilled effective wage in (2) and (3) can be rewritten as:

$$(1+\tau)\, w_H = Af'(n), \quad w_L = A\left[f(n) - nf'(n)\right],$$

where $Af(n) = AF[n, 1] = Y_U/N_L$. As w_H is decreasing in n while w_L is increasing in n, the skilled-unskilled wage ratio is decreasing in n. Defining n_s such that $w_H h/w_L = 1$ when $n = n_s$, we impose the following condition:

Condition S $w_H(n_s)\, h = w_L(n_s) > B + \sigma$.

If Condition S holds, then any urban job pays (net of the migration cost) better than the rural job. To better understand Condition S, we plot the high- and low-skilled wages against n in Figure 3. Condition S requires that urban wages, net of migration costs, are higher than rural wages. It is a condition to guarantee that, if children can find a job in cities, rural parents will send them to urban areas to attend college. Our next concern is the likelihood of finding a job in the urban area. We impose an assumption on the probabilities of acquiring an urban job: the probability of finding an *urban* job via education must be higher than that of finding one through other channels.

Assumption 1 $\gamma_H + \gamma_L > \pi$.

Assumption 1 states that the probability of securing an urban job after receiving a college education cannot be lower than the probability that a rural worker finds an urban job through non-educational channels. Thus, Condition S and Assumption 1 together imply that the expected urban wage income is higher than the rural wage income. As a result, rural parents will consider sending their children to cities to attend college. To present our finding formally, we separate the effect of migration of

(12) into two:

$$\begin{aligned}\Delta^i\left(\mathbf{I}^k, x^j\right) &= \underbrace{u\left(w_R - x^j - \sigma - \phi^i\right) - u\left(w_R - \phi^i\right)}_{\text{direct consumption effect}} \\ &\quad \underbrace{+\beta\mathbb{E}_{\mathrm{X}}\left\{u\left(c_U^j\right) - u\left(c_R^j\right)\right\}}_{\text{intergenerational effect}}.\end{aligned}$$

The direct consumption effect is always negative because parents' consumption is lower due to the education and migration costs, whereas the intergenerational effect is ambiguous. Condition S and Assumption 1 together assure that the intergenerational effect is positive which is necessary for parents to send their children to cities to attend college:[11]

Proposition 1 *Under Assumption 1 and Condition S, the intergenerational effect of migration is positive.*

The intuition of the above proposition is straightforward. If the probability of finding an urban job via education is reasonably high (Assumption 1) and rewarding (Condition S), then the higher expected urban wage provides an incentive for parents to pay the educational and migration costs of their children's education via altruism. Otherwise, this choice would not be a good "investment" from the parents' perspective. Thus, we conclude

Corollary *Under Assumption 1 and Condition S, if the positive intergenerational effect dominates the negative direct consumption effect, then parents will send their children to cities to attend college.*

3.3 Comparative statics

In the following, we examine how the net gain in education $\Delta^i\left(\mathbf{I}^k, x^j\right)$ responds to changes in the parameterization, i.e., we examine whether the "marginal" parent (a parent who is indifferent between sending her child to attend college in an urban area or keeping the child in the rural area so that $\Delta^i\left(\mathbf{I}^k, x^j\right) = 0$) will send her child to receive an education. Based on the straightforward computation of comparative statics, we obtain the following proposition:

Proposition 2 *Under Condition S and Assumption 1, more parents will be willing to send their children to urban areas to attend college*

[11] All the proofs are relegated to Appendix B.

1. *when their children become more talented ($z_j \uparrow$), or when education becomes cheaper ($b \downarrow$).*

2. *when the chances that their children can obtain an urban job are higher ($\gamma_H \uparrow$, $\gamma_L \uparrow$).*

3. *when the chance of being low-skilled workers decreases ($\pi \downarrow$).*

Finally, to examine how changes in migration costs (σ) affect parents' decisions, we compute:

$$\frac{d\Delta^i\left(\mathbf{I}^k, x^j\right)}{d\sigma} = -u^i_{c_U} - \beta \mathbb{E}_{\mathrm{X}} \left\{ u^j_{c_U} \left(1 - \gamma_H - \gamma_L\right) \mathbf{I}^k\left(X\right) - u^j_{c_R} \left[\pi + \left(1-\pi\right) \mathbf{I}^k\left(X\right)\right] \right\}.$$

The first term on the RHS highlights the standard negative direct effect of an increase in the migration cost on parents' consumption. However, once the child is sent to the urban area, the higher future migration cost of the grandchild can be saved. This indirect or intergenerational positive effect on the migration cost is captured by the second term on the RHS (which is shown to be positive below). Thus, we can conclude the following:

Proposition 3 *Under Condition S and Assumption 1, if the intergenerational effect dominates the direct consumption effect, then more parents will be willing to send their children to attend college in urban areas when the migration cost increases.*

3.4 Evolution of workers

In this section, we study the population dynamics of rural-urban migration. Recall that adult agents supply labour to the market and that each agent gives birth to only one child, so the entire adult population participates in the labour market. Let $\left(N^t_H, N^t_L\right)$ be the skilled and unskilled workers in the urban area and N^t_R be the rural labour force, all at time t. Denote $J, K = \{H, L\}$ as the type of jobs for generation-j and generation-k urban workers. Let δ_{JK} be the transitional probability for an urban generation-k worker born to a generation-j urban worker with job J, working as a type K worker in an urban area. Thus, δ_{JK} captures job mobility across generations in the urban areas. In general, we expect that $\delta_{JJ} > \delta_{JK}$ for $J \neq K$, implying that the child is more likely to work as a type-J worker when the parent is a type-J worker. Under the assumption that the *residences* of urban households are passed from one generation to another, we have:

$$\sum_K \delta_{JK} = 1. \tag{13}$$

Then, the populations of skilled, unskilled and rural labourers evolve according to the following law of motion equations:

$$
\begin{aligned}
N_H^{t+1} &= \delta_{HH} N_H^t + \delta_{LH} N_L^t + N_R^t \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \gamma_H dG(z^j), && (14)\\
N_L^{t+1} &= \delta_{HL} N_H^t + \delta_{LL} N_L^t + N_R^t \left\{ \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \gamma_L dG(z^j) + \int \left[1 - \mathbf{I}^j\left(z^j, \mathbf{I}^k\right)\right] \pi dG(z^j) \right\}, && (15)\\
N_R^{t+1} &= \left(1 - \delta_{HH} - \delta_{HL}\right) N_H^t + \left(1 - \delta_{LH} - \delta_{LL}\right) N_L^t \\
&\quad + N_R^t \left\{ \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \left(1 - \gamma_H - \gamma_L\right) dG(z^j) + \int \left[1 - \mathbf{I}^j\left(z^j, \mathbf{I}^k\right)\right] \left(1 - \pi\right) dG(z^j) \right\}, && (16)
\end{aligned}
$$

where the initial urban and rural labour forces are denoted by N_H^0, N_L^0 and N_R^0, respectively. Using (13), we can simplify (14)–(16) as follows:

$$
\begin{aligned}
N_H^{t+1} &= \delta_{HH} N_H^t + \left(1 - \delta_{LL}\right) N_L^t + N_R^t \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \gamma_H dG(z^j), && (17)\\
N_L^{t+1} &= \left(1 - \delta_{HH}\right) N_H^t + \delta_{LL} N_L^t + N_R^t \left\{ \pi + \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \left(\gamma_L - \pi\right) dG(z^j) \right\}, && (18)\\
N_R^{t+1} &= N_R^t \left\{ \left(1 - \pi\right) - \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \left(\gamma_H + \gamma_L - \pi\right) dG(z^j) \right\}. && (19)
\end{aligned}
$$

Finally, combining (17) and (18), we can see that the *residences* of urban households are passed from one generation to another:

$$
N_U^{t+1} = N_U^t + N_R^t \left\{ \pi + \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) \left(\gamma_H + \gamma_L - \pi\right) dG(z^j) \right\},
$$

where $N_U^t \equiv N_H^t + N_L^t$ denotes the total urban workforce at time t.

Figure 4 plots the flows of workers in the model economy. For the quantitative analysis in the next section, we will focus on the case where all high-skilled parents produce high-skilled children, i.e., $\delta_{HH} = 1$.

3.5 Equilibrium

In equilibrium, all labour markets clear under the factor prices $\{w_H, w_L, w_R\}$ given by (2), (3) and (6):

$$
N_J^{dt} = N_J^t, \quad J = H, L, R, \tag{20}
$$

where N_J^{dt} denotes labour demand of type J. In addition, there is the overall population restriction for each period:

$$
N_H^t + N_L^t + N_R^t = N, \tag{21}
$$

where N is the constant population size in each period.

To conclude this section, we define the competitive equilibrium for our model.

Definition. *A **dynamic competitive spatial equilibrium** (DCSE) of the model consists of migration choice* $\{\mathbf{I}^j\}$ *and wage rates* $\{w_H, w_L, w_R\}$*, such that*

(i) *(Optimization)* given *wage rates* $\{w_H, w_L, w_R\}$, $\{\mathbf{I}^j\}$ *solves (7) subject to (9), (10) and (11);*

(ii) *(Market clearing) wage rates* $\{w_H, w_L, w_R\}$ *satisfy (2), (3) and (6), and labour markets clear according to (20); and*

(iii) *(Population identity) given the initial population* $\{N_H^0, N_L^0, N_R^0\}$ *and the distribution of talent* $G(z^j)$*, the population evolves according to (17)–(19) and is restricted by identity (21).*

4 Quantitative Analysis

As discussed in the introduction, we are interested in studying the effects of the education-based migration and migration regulations on the Chinese economy within the post-reform regime but before the financial tsunami, namely, the 1980–2007 period. Because the GJA policy was eliminated in 1994, it is natural to break the entire period into two sub-periods: Regime 1, spanning from 1980 to 1994, and Regime 2, ranging from 1995 to 2007. We first conduct the two-regime calibration by fitting the model to the Chinese data. Based on the calibrated parameters, annual urban TFPs and distortions τ are drawn out. We then simulate the model from 1980 to 2007 based on the parameters obtained in the two-regime calibration, allowing TFPs and distortions to vary annually. Finally, the simulated economy is taken as our benchmark model and we proceed to perform analyses on decomposition and policy experiments to examine the roles of education-based migration in China's development.

4.1 Calibration and simulation

As mentioned in Section 3, we assume that the residences of urban households are passed from one generation to another. Since college students usually enjoy cheaper rental rates and meals compared to migrant workers, we distinguish the migration cost (σ) in the model into two types to better describe the reality: education-based migration cost (σ_e) and work-based migration cost (σ_w). We focus on a special case of the model: no reverse migrations are considered and upward mobility is allowed.[12] Data sources and the details of data computation are summarized in Appendix C.

4.1.1 Two-regime calibration

The model period is 25 years. There is no population growth in the model, so total population is normalized to one in every period. Urban (rural) population in the model is thus equal to the share of urban (rural) to total population. They are computed using the data on populations by rural and urban residence. We term workers with educational attainment of college and above (below) as high (low)-skilled according to the model. Then, using the data on urban employment by educational attainment and the share of urban population, we compute the stocks of high- and low-skilled workers.

To proceed with calibration, we assume that the utility function takes the standard CRRA form:

$$u(c) = \frac{c^{1-\varepsilon} - 1}{1-\varepsilon}, \quad \varepsilon > 1,$$

where ε is the inverse of the elasticity of intertemporal substitution (EIS). In the literature, the Pareto distribution is commonly associated with wealth and income, which are believed to be closely related to one's talent. Therefore, we assume that children's talents z^j follow a Pareto distribution, with the CDF given by:

$$G\left(z^j\right) = 1 - \left(\frac{z_{\min}}{z^j}\right)^{\theta}, \quad z^j \geq z_{\min},$$

where $z_{\min}$ and θ are the location and shape parameters of the Pareto distribution, respectively. Below, we first describe the preset common parameters and then the preset regime-specific parameters. The values of these parameters are taken from the literature, from data, or by assumption. We then elaborate on the methods of identifying the remaining parameters with model equations and data moments.

China is well known for its high saving rates, and the annual time preference rate of China in the literature is usually very low. We thus set the annual time preference at 1 per cent, which is close to the value reported by Song et al. (2011). Assuming that parents love their children as they love themselves, the parental altruistic factor for children β is hence equal to 0.7798. Regarding the inverse of the EIS parameter ε, we set $\varepsilon = 1.5$ as this is a common value in the literature.

[12] This is true from the macro perspective. Net flows from rural to urban areas have always been positive. Additionally, the average years of schooling in China for people aged 15 and over have increased from 4.86 years in 1980 to 7.51 years in 2010, showing an overall pattern of increasing educational attainment.

There is no nationwide survey of child-rearing costs for rural China. Zhu and Zhang (1996) estimated that the average child-rearing cost in rural villages in Xianyang, which is located in the Shaanxi province of China, was approximately 17.4 per cent of family income for a child aged 0–16 in 1995. Therefore, we set ϕ such that the child-rearing cost is 17.4 per cent of rural household income in both regimes. For the Pareto distribution parameters, we set $z_{\min}$ to one following the literature on firm size distribution, productivity and international trade.[13] Since talents are unobservable but are found to be correlated with income levels, we compute θ using 1995 and 2002 rural household net income data from the Chinese Household Income Project (CHIP) and obtain a value of 2.5.[14] The last preset common parameter is the elasticity of substitution between high- and low-skilled labour in the production function $1/(1-\rho)$. In the literature, the estimates for developed countries range from 1 to 3,[15] while the estimated values for Asian economies are larger, mostly falling between 2 and 7.[16] We thus choose the elasticity of substitution between high- and low-skilled labour to be 3 so that ρ is equal to 0.6667.

The migration cost is categorized into education-based (σ_e) and work-based (σ_w) migration cost. Considering migration costs as urban living costs and the required costs for moving to urban areas, we compute σ_w from CHIP 2002 and obtain a value of 55.54% and 30.79% of rural household income for regimes 1 and 2, respectively.[17] As for the education-based migration cost σ_e, He and Dong (2007) reports the annual cost of food and dormitory for a college student in 1996-2005. On average, it is about 63.78% of annual rural household income during 1996-2005. Assuming that all students stay in college for four years and adjusting for model periods, we obtain σ_e=0.1021 for regime 2. Since there is no data prior to 1996, we compute σ_e for regime 1 by assuming that

[13] See, for example, Ghironi and Melitz (2005), Mayer, Melitz and Ottaviano (2014), Bernard et al. (2003), and Eaton and Kortum (2002).

[14] Note that this number is close to the average of the estimated θ for the period of 1950–1990 in the U.S., which is equal to 2.11 as reported by Feenberg and Poterba (1993). The details of computation for θ are relegated to Appendix C.

[15] See, for example, Autor, Katz and Krueger (1998), Acemoglu (2003) and Ciccone and Peri (2005).

[16] 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.

[17] Tombe and Zhu (2015) found a high moving cost for Chinese migrant workers, roughly equal to the annual income of a rural worker. For the U.S., the estimated migration costs are between one-half and two-thirds of average annual household income (Bayer and Juessen, 2012; Lkhagvasuren, 2014). Our work-based migration cost is consistent with the literature.

σ_e and σ_w grow at the same rate between the two regimes and obtain regime 1 σ_e=0.1841. For the two parameters in the education cost a and b, we interpret a as the parameter controlling the admission selectivity of *gaokao,* and b as the parameter capturing the cost directly related to college education, such as expenses on textbooks, stationary, materials and tuitions. a is pinned down by model equations. The determination of a will be addressed later. Using Urban Household Survey (UHS) 2007 and 2008, b equals 0.48% and 5.28% of rural household income in regimes 1 and 2, respectively.[18] The sharp change in b captures the increase in college tuition in the late 1990s of China.

Other preset parameters are described as follows. The rural production technology is linear, so the rural technology scaling factor B is equal to the rural wage rate. Being interested in determining the relative economic positions of rural and urban China and how regional technological disparities shape individuals' migration decisions, we normalize rural per capita income in 2007 to 1, i.e., B of 2007 is 1. With this normalization and the time series data on rural per capita income, we compute the normalized rural per capita income over 1980–2007. Then, we compute the averages of the rural per capita income in the two regimes and obtain B values of 0.3685 and 0.7177 for regimes 1 and 2, respectively. It is notable that such normalization of rural per capita income together with the choice that $z_{\min}$ is 1 imply that not all rural parents can afford to send their children to college: only those with relatively talented children are affordable to do so. This is because rural parents have to pay for their own consumption as well as the child-rearing cost in addition to college tuition and education-based migration cost – if they send their children to college.

We now turn to the rates at which college graduates find jobs and the migration probability for rural workers. All the job finding probabilities are the probabilities facing by each cohort. In line with the GJA policy, all college graduates were assigned jobs (either in the government or in state-owned enterprises) before 1994; thus, we set $\gamma_H = 1$ and $\gamma_L = 0$ in regime 1, meaning that college graduates from rural China face a full employment rate ($\gamma_H + \gamma_L$). For the second regime, no data are available on the employment rate of college graduates from rural China. We thus use urban employment rates from CHIP in 1995, 2002 and 2007 to proxy for the employment rate of

[18] Note that college education was almost free of charge before 1990. Thus, the value of b in regime 1 includes stationary, materials and textbooks, while the value of b in regime 2 includes stationary, materials, textbooks and college tuitions. Both are adjusted for model periods. College tuition as a percentage of rural household income ranges from 22.8% in UHS to 35.2% in CHIP. We therefore assume college tuition is 30% of rural household income in the computation of b in regime 2.

college graduates from rural areas. The average value, 0.9209, is set to be the employment rate in city districts for college graduates in regime 2. Note that γ_L is the job mismatching rate for college graduates, which we do not have information for. Believing it to be low, we set γ_L to 0.05, and γ_H is thus solved as 0.8709 in regime 2.[19,20] For the probability of work-based migration π, as there is no nationwide survey on rural-urban migration in China during the periods that we examine, we use changes in urban population as a proxy for rural-urban migration flows.[21] We believe that the actual rural-urban migration flows were higher because China adopted a much looser one-child policy in rural areas than in urban areas. We first compute the total number of migrant workers by multiplying changes in urban population by the percentage of migrants who migrated due to employment reasons (columns 3–5 in Table 1, the average of 1985 and 2000). Then we divide the total number of migrant workers by the rural population to obtain the probability that a rural worker migrates to a city for employment. As reported in Table 2, the average migration probabilities for rural workers π in regime 1 and regime 2 are 0.0036 and 0.0083, respectively.

Next, we compute the human capital possessed by high-skilled workers relative to low-skilled workers, h, based on the Mincerian method. To do this, we first compute the average years of schooling for those with less education than college and those with college or above from the data. The average years of schooling below college were 8.02 and 8.95, and the average years of schooling for college and above were 14.1 and 14.52 in regimes 1 and 2, respectively. In addition, the Mincerian coefficients of returns to education reported by Zhang et al. (2005) over 1988–1994 and 1995–2001

[19] The calibration results are not sensitive to our choice of γ_L.

[20] China has experienced huge reform in the public sector in the late 1990s. Lots of workers were "off post" or *xiagang* during the reform. These workers still have their hukou with their employers (and hence stay in cities) as only by doing this they can get compensations for the loss of their jobs. *Xiagang* workers are usually low-skilled workers, senior in age and difficult to find a job again. See Lee (2000) for more information on *xiagang* workers. From a macro perspective, we only distinguish "urban" versus "rural" and do not distiguish employment opportunities (private or public) in urban areas. In the calibration, we have matched the N_H/N_L data series and considered *xiagang* when computing urban employment rate. Therefore, the employment composition change due to the reform is being taken care of.

[21] Although Longitudinal Survey on Rural Urban Migration in China provides migration information, it only starts in 2008, which is not the period that we examine in this paper. We are aware that changes in urban population is equal to rural-urban migration only if births and deaths in urban areas are exactly net out. However, we find that the net birth rates (net of death) in urban and rural areas are quite stable during the periods that we examine. Since there is no available nationwide data on rural-urban migration, we use changes in urban population as a proxy. See Appendix C for the details.

are 0.0497 and 0.0836, respectively, and we take these two numbers as our Mincerian coefficient for regimes 1 and 2. Thus, the computed regime-specific h for regimes 1 and 2 are 1.3529 and 1.5928. The last preset parameters are those for intergenerational mobility. Based on the assumptions that the residences of urban households are passed from one generation to another, no reverse migrations are considered and only upward mobility is allowed, $\delta_{HH} = 1$, $\delta_{HL} = 0$ and $\delta_{LH} + \delta_{LL} = 1$ in both regimes. The method of calibrating δ_{LL} will be described later.

Other parameters are calibrated to match data moments and/or are solved by model equations. The probabilities of remaining low-skilled workers across generations (δ_{LL}) in the two regimes are calibrated to match the N_H/N_L ratios of both regimes. To perform this calibration, we first compute the *zhaosheng* flows from the data (reported in Table 2) following the same method to compute the total number of migrant workers. Based on the computed *zhaosheng* flows and the evolution of workers equations (17)-(19), the stocks of rural workers, high- and low-skilled workers from the model are obtained, and the model implied N_H/N_L ratios can thus be computed. The δ_{LL} in the two regimes are solved such that N_H/N_L ratios in the model match the regime specific N_H/N_L ratios in the data, which are equal to 0.9996 and 0.9883 for regimes 1 and 2, respectively. The decreasing δ_{LL} shows that intergenerational mobility in China has improved over the 1995–2007 period.

The regime-specific distortion τ faced by urban firms when hiring high-skilled workers, the urban TFPs A in the two regimes, the CES production high-skilled labour share α and the non-homothetic term ψ are calibrated to match the regime average skill premiums ($w_H h/w_L$), urban premiums (w_L/w_R) and urban output shares (Y_U/Y). Note that $\psi > 0$ in the CES production function implies decreasing returns to scale technologies, and ψ can be perceived as an urban infrastructure or producer rent that is used to facilitate production in cities. Therefore, the targets of urban output shares contain additional information besides employment and wage measures, and these can serve to calibrate both α and ψ.

Specifically, from the skill premium equation and skill premium data, the regime-specific distortions τ are derived as functions of α and ψ. Similarly, the urban TFPs in the two regimes are derived as functions of α and ψ from the urban premium equation and data. Finally, the CES production parameters α and ψ are calibrated to match the urban output shares in regimes 1 and 2. The calibrated α and ψ values are equal to 0.8461 and 0.0618, respectively. The regime-specific distortions τ are 7.1103 and 5.4763 while the urban TFPs in the two regimes are equal to 5.3877 and

11.0573, respectively. Our results show that relative to rural TFP, urban TFP is growing faster: the implied annual urban TFP growth rate is 5.47 per cent. In addition, the distortion τ faced by urban firms in regime 2 is reduced by more than 22 per cent compared to that in regime 1, indicating that the market distortions due to the planned economy have been greatly alleviated.

The last parameter to be calibrated is the college admission selectivity a, and we will use the indifference boundary equation (12) to identify it. Let $\hat{z}$ denote the threshold in children's talent such that when a child is equipped with the talent $\hat{z}$, his parents are indifferent between sending him to college or keeping him at home. In other words, when a child is talented such that $z^j \equiv 1/\left[a\left(x^j - b\right)\right] \geq \hat{z}$, his parents will definitely send him to college ($\Delta^i(\mathbf{I}^k, x^j) \geq 0$). The endogenous threshold $\hat{z}$ therefore dichotomizes the "destiny" of rural children, determining whether they belong to the "sent" group or the "kept" group. Specifically, define $\tilde{N}_E^t$ as the *zhaosheng* flow at time t. $\tilde{N}_E^t$ can be written as:

$$\tilde{N}_E^t = N_R^t \int \mathbf{I}^j\left(z^j, \mathbf{I}^k\right) dG(z^j) = N_R^t \left(\frac{z_{\min}}{\hat{z}}\right)^{\theta}. \tag{22}$$

Therefore, $\hat{z} = z_{\min}(N_R^t/\tilde{N}_E^t)^{1/\theta}$ and $\hat{z}$ can be directly computed using the data for *zhaosheng* flows. The computed average $\hat{z}$ for regimes 1 and 2 are equal to 17.7632 and 13.1391, respectively. The decrease in $\hat{z}$ indicates that more rural students are going to colleges. With $\hat{z}$, we can now solve the college admission selectivity a from the indifference boundary equation. The calibrated a are 1.1489 and 0.4701 for regimes 1 and 2. The decrease in a reflects the fact of the draining in rural talents so that college admission is becoming more selective for rural students. This is consistent with the data that it becomes more difficult for rural students to attend top universities in China. In sum, our framework captures the main spirit of education reform in China: the lower threshold $\hat{z}$ denotes the college expansion, the smaller a implies the rising admission selectivity for rural students, and the increase in b captures the fact that college education becomes more expensive. They all affect the decision on education-based migration in our model. Table 3 reports the calibration results.

Based on the above parameters, our next step is to calibrate the annual urban TFP and distortions for the 1981-2007 period and to perform a simulation to serve as our benchmark model. Once the benchmark model is obtained, we are able to decompose the effects of education-based and work-based migration on the macroeconomic variables and conduct policy experiments.

4.1.2 Calibration of the annual urban TFP, distortions and simulation

In the two-regime calibration, we target the regime average urban premium (w_L/w_R) and skill premium ($w_H h/w_L$) to calibrate the regime-specific urban TFP A and distortion τ. Similarly, here, the annual data for the urban premium and skill premium are targeted to calibrate the annual urban TFPs and distortions. Before solving the time series of A and τ, we have to determine the annual N_R, N_H, N_L and human capital for high-skilled workers h. The procedure is described as follows.

We first compute the annual N_R, N_H and N_L based on the model. To do so, we again use annual changes in urban population to proxy for rural-urban migration flows and multiply these migration flows by the percentage migration due to studying or training (column 6 in Table 1, average of 1985 and 2000) to obtain annual *zhaosheng* flows. Using the *zhaosheng* flows between 1980 and 1981, the 1980 data on N_R, N_H and N_L and the parameters determined in the two-regime calibration (including γ_H, γ_L, π, δ_{HH}, δ_{HL}, δ_{LH}, δ_{LL} and θ), we solve the threshold $\hat{z}$ for 1980 based on (22) and the 1980–1981 work-based migration flows according to the following formula: Work-based migration flow$_t = \pi N_R^{t-1}\left[1-(z_{\min}/\hat{z})^{\theta}\right]$. Then, from the evolution of workers equations (14)–(16), we can compute the model implied N_R, N_H and N_L for 1981. By repeating this process, we obtain an annual series of the threshold $\hat{z}$ as well as of N_R, N_H, and N_L.

We next turn to determine the annual human capital series for high-skilled workers h. Recall that in the two-regime calibration, we use a Mincerian method to compute h, which equals 1.3529 and 1.5928 in regimes 1 and 2, respectively. To obtain annual h, we further assume that the annual growth rate of human capital is constant over the 1980–2007 period. The annual series of h is computed so that the average human capital in regimes 1 and 2 are exactly equal to those in the two-regime calibration. Finally, with the time series data for rural per capita income (with 2007 data normalized to one) and the urban premium and skill premium equations, the annual urban TFP A and distortions τ are solved such that the urban premium and skill premium implied by the model exactly match the data.

Figure 5 plots the calibrated urban TFP and rural TFP for 1981–2007. It can be observed that the urban TFP grows relatively faster than the rural TFP after 1985, corresponding to China's economic reform, the privatization of state-owned enterprises and the deregulation of price controls. As reported in Table 3, the relative urban-rural TFP growth rate over our sample period is approximately 0.39 per cent per year. Figure 6 provides a comparison between the model and the data on urban per capita output and total output per capita.[22] We define the urbanization rates in the model as the shares of urban workers. Figure 7 compares the model to the data on urbanization rates and the stocks of urban high- and low-skilled workers. Our model shows a lower urbanization rate and a smaller stock of low-skilled workers than do the data, with the discrepancies between the model and the data widening over time. The gaps can be explained by the migration flows inputted when we calibrate the model. Because our model only considers two channels of migration, the data on migrants who migrated for non-educational and non-employment reasons (accounting for approximately 50 per cent of total migration) are thus excluded in the calibration. However, these migrants could migrate due to other reasons but became low-skilled workers later. As a result, our model underestimates the stock of low-skilled workers and the urbanization rate. As the model generates fewer workers in urban areas, especially fewer low-skilled workers, the urban per capita output in the model is slightly higher than that observed in the data. Additionally, as there are more rural workers in the model and rural technology is less productive, total output per capita in the model is slightly lower than that observed in the data.

This simulation serves as our benchmark model for the decomposition analysis and for the policy experiments. Table 4 summarizes the annual averages of important macroeconomic variables in the benchmark model for regimes 1 and 2 as well as for the entire sample period. As expected, total output per capita in regime 2 is more than double that in regime 1, urban output shares increase, and urban employment shares increase. These imply that urban production becomes more important in regime 2. Furthermore, our model shows that the high-skilled employment shares in urban areas in regime 2 are more than quadruple the shares in regime 1, while the skill premium still increases. These trends are all consistent with the experience of China's development.

4.2 Decomposition: The contributions of *zhaosheng* and work-based migration

To identify the contribution of each migration channel and to study the total effects of migration on China's development process, we eliminate the migration channels sequentially. The effect of the channel under study is thus the difference in results between the model with the channel being excluded and the benchmark model.

Figure 8 plots urban per capita output, total per capita output, and urbanization rates under

[22] Based on equations (1) and (5), we use the N_H, N_L and N_R data to calculate urban per capita output and total output. See Appendix C for details.

the decomposition. The benchmark model and the three scenarios are plotted for comparison: (1) work-based migration is eliminated; (2) *zhaosheng* is eliminated; and (3) both migration channels are eliminated. In the first scenario, when the work-based migration is eliminated, the only "new" source of low-skilled workers coming from countryside is unlucky college graduates. Consequently, there are much fewer productive low-skilled workers in cities, resulting in a larger high-to-low skilled labour ratio and a higher urban per capita output. Furthermore, as the migration volume via the work-based migration is large, the urbanization rate in this scenario is much lower than the benchmark case. In the second scenario in which *zhaosheng* is eliminated, once again, as the volume of migration through the *zhaosheng* channel is small, the urbanization rate in this case is very close to that in the benchmark model. This shows that the majority of rural-urban migration is work-based. With fewer productive high-skilled workers in the cities, urban per capita output is now slightly lower than that in the benchmark case.

To identify the magnitude of the contribution of migration types to major macroeconomic variables, Table 5 reports the percentage change relative to the benchmark model for the above three scenarios. Given the large volume of work-based migration, the conventional wisdom is that the effects of work-based migration on output levels should far outweigh the effects of education-based migration. However, our results in Table 5 show that the contribution of education-based migration cannot be overlooked: *zhaosheng* and work-based migration explain 6.3 per cent and 4.5 per cent of total output per capita in the benchmark model over the entire sample period, respectively.[23] We also find that *zhaosheng* contributes to roughly one-third of the high-skilled employment share in the benchmark model and thereby lowers the skill premium, while work-based migration reduces the high-skilled employment share and boosts the skill premium. Furthermore, the result suggests that *zhaosheng* is more important in regime 2 than in regime 1: *zhaosheng* in regime 2 explains 8.0 per cent of total output per capita in the benchmark model, while it only explains 2.0 per cent of total output per capita in regime 1. There are several conflicting forces influencing the effects of *zhaosheng*: a higher skill premium and higher human capital level in regime 2 attract more migration through the *zhaosheng* channel, whereas the higher migration cost and the termination of the GJA policy depress education-based migration. Our quantitative results show that the two positive effects dominate the two negative effects. The effects of *zhaosheng* on total output per capita and

[23] Our framework does not consider spillover effects in cities, as mentioned in Lucas (2004). If low-skilled workers can benefit from high-skilled workers in urban areas, the role of education migration in our model will be even more important.

urban employment share in regime 2 are larger than those in regime 1.

As shown in Table 5, our results also show rich interactions between *zhaosheng* and work-based migration on the skill premium, high-skilled employment share, total output per capita, and urban output and employment shares. It is intuitive that the interactive effect is strongest on the high-skilled employment share (accounting for 11 per cent of its change over the entire sample period) because work-based migration leads to a higher skill premium that attracts more education-based migration. For the other variables, several conflicting forces are involved in the resulting interactive effect. First, if work-based migration is not allowed, rural residents can still move to urban areas via the *zhaosheng* channel. Second, high-skilled workers (mainly from *zhaosheng*) and low-skilled workers (mainly from work-based migration) are substitutes in production. Third, when there is a larger stock of low-skilled workers in the cities, the skill premium is boosted up. The higher skill premium thus encourages more parents to send their children to cities to attend college. Fourth, there exists upward intergenerational mobility. The last two forces are positive, while the first two are negative. The results show that the skill premium is the dominant effect; thereby, a minor but positive interaction between *zhaosheng* and work-based migration is observed.

4.3 Ten-factor decomposition in regime 2

China experienced huge changes in the past decades, such as institutional reforms on education, market intervention and migration regulation. Here we provide a ten-factor decomposition in regime 2 to study the contribution of each factor of our concern to the development of China. The ten factors refer to the abolishment of the GJA policy (lower γ_H in regime 2), better work-based job opportunities (higher π in regime 2), an increase in the absolute value of education-based migration cost, an increase in the absolute value of work-based migration cost, increases in both urban and rural TFP, an increase in the absolute value of child-rearing cost, less market distortion (lower τ in regime 2), better intergenerational mobility (lower δ_{LL} in regime 2), rising admission selectivity (lower a in regime 2), and an increase in college tuition (higher b in regime 2). Each experiment is conducted by setting the corresponding parameter back to the level of regime 1, while others remain unchanged. The percentage change relative to the regime 2 benchmark model (as reported in Table 4) is then computed.

The results of the ten-factor decomposition are provided in Table 6 and are summarized below. First of all, the TFP growth and the better intergenerational mobility contribute the most to the increases in the total output per capita, accounting for 52.9% and 12.3% respectively, whereas the rising admission selectivity greatly damp the total output per capita (depressed by 24.8%). Secondly, the better intergenerational mobility and the TFP growth also matter for the increase in urban output share, accounting for 3.2% and 1.8% of the increase, respectively. However, the effect is offset by the rising admission selectivity (-4.9%). Third, urban employment share rises due to better work-based job opportunities, accounting for 8.2% of the increase, but is depressed by the rising admission selectivity (-12.4%). Fourth, intergenerational mobility and TFP growth are both important in increasing the skilled employment share (accounting for 49.3% and 5.5% respectively), whereas the skilled employment share is decreased by the rising admission selectivity, the higher college tuition and better work-based job opportunities (-64.2%, -6.1% and -7.3%, respectively). Finally, lower labor market distortions and the rising admission selectivity both lead to a higher skilled premium, whereas the improvement in intergenerational mobility drag the skilled premium down.

Compared with other factors, we find that the rising college admission selectivity plays a crucial but negative role in China's development during 1994-2007. Admissions are becoming more selective for rural students. This could be due to the fact that skilled parents tend to move to cities, resulting in the brain drain phenomenon from rural to urban areas. Since it is more difficult for rural students to attend top universities, rural parents have lower incentives to send their children for higher education in urban areas (fewer education-based migration). This will hurt the high-skilled employment share, the urban employment share, the urban output share and the total per capital output.

4.4 Policy experiments

Based on the benchmark model, we are now ready to provide policy experiments. Two experiments are conducted in this section. The first one is related to the education-based migration, discussing the scenario without the GJA policy throughout the history in China. As the GJA had been in force in China from the 1950s to the mid 1990s, we wonder how would the economy perform if China had not implemented the GJA policy throughout its history. The second experiment explores the effect of a more relaxed regulation on the work-based migration since 1980. Because of the *hukou* reforms, the regulations on work-based migration have been gradually relaxed. We are curious what China would look like if the government had maintained looser regulations for migrant workers. Table 7 summarizes the percentage changes relative to the benchmark model for the two experiments. The details are given below.

In the first experiment, the value of γ_H in regime 1 is set to that of regime 2. That is, jobs are not guaranteed for college graduates in regime 1 anymore. As shown in Table 7, there are two opposite effects of this policy. Without guaranteed high-skilled jobs, college education becomes less rewarding, resulting in fewer education-based migration. However, the skill premium increases because of the decreasing supply of high-skilled workers, which makes college education more rewarding. Our quantitative result suggests that the former effect is larger. Therefore, without the GJA policy throughout the history, urban employment would decrease by 0.5 percentage, the share of high-skilled employment would decrease by approximately 7 percentage, the skill premium would increase by 0.7 percentage and the total output per capita would decline by 1.2 percentage. We thus conclude that the impact of no GJA on China's development is relatively small. The only more negative effect of not having the GJA is that the high-skilled employment share is smaller. The minor effect of no GJA could be due to the fact that the rate at which college graduates find jobs in the benchmark model is very close to one.

In the second experiment, the value of π in regime 1 is increased to that of regime 2. The result in Table 7 suggests that, with a relaxed regulation on work-based migration, there would be more work-based migrants, resulting in a larger share of urban employment and an increase in both urban output share and total output per capita. However, the relaxation leads to a lower share of high-skilled employment; thereby a higher skill premium. Compared with the GJA policy, the regulation on work-based migration has a larger impact on China's urbanization and development.

5 Conclusions

Rapid economic growth and associated rapid urbanization in China have recently aroused great interest in academia. In this paper, we have examined the causes and consequences of rural-urban migration in the Chinese economy, with a special focus on a non-conventional migration channel: education-based migration or *zhaosheng*. We have calibrated our dynamic spatial equilibrium model and conducted a decomposition analysis to quantify the effects of education-based and work-based migration on the development process of China. We have also performed policy experiments on labour-market regulations.

The main takeaway of our quantitative analysis is that migration indeed contributes greatly to the development of China: rural-urban migration accounted for nearly 11 per cent of per capita output throughout the 1981-2007 period, while the effects of education-based migration is larger than that of work-based migration, explaining 6.3 and 4.5 per cent of output per capita, respectively. Because of the considerable impact of education-based migration, ignoring the education channel would severely under-estimate the effects of migration, particularly the skill-enhanced process of migration. Moreover, because the two channels interact in a dynamic equilibrium, substituting for as well as complementing each other, there are rich reallocation effects that are often omitted in the absence of the education channel. Exactly because of such rich interactions, our decomposition analysis indicates that the education channel is more important in accounting for China's rapid development and urbanization processes. Furthermore, our results suggest that the more selective college admission for rural students plays a significantly negative role in the development of China, especially lowering the high-skilled employment share seriously.

Our quantitative analysis has also generated important policy implications. Because the effects of the government job assignment policy for the college-educated is found to be marginal, the adoption of a market-oriented labour policy causes no harm. Besides, mitigating migration barriers and promoting intergenerational mobility in urban areas (via equal opportunities for education or redistributive tools on bequests and transfers) are found to be crucial for the development and urbanization processes in China.

Along these lines, it would be interesting to extend the framework developed in this paper to study various migration issues in developing countries. A possible extension is to allow urban unskilled workers to accumulate human capital in cities, as in Lucas (2004). This will further enhance the importance of the education-based migration channel. Another extension might examine different underlying channels of the work-based migration, in particular, the early sample stage of the *zhaogong* channel into state-owned enterprises and the later stage into both state-owned enterprises and private sector jobs. Moreover, the investment-oriented channel via the blue-stamp scheme for setting up private businesses as well as investments in properties and factories is worth exploring. We will leave these topics for future research.

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Table 1: Migration by reasons

Year	Population outflow	Job Transfer	Job Assignment	Work or Business	Study or Training	Other reasons
Percentage						
1985	100.00	29.57	8.04	3.08	11.26	48.05
2000	100.00	5.32	3.76	33.55	6.84	50.53
Average	100.00	17.44	5.90	18.32	9.05	49.29
Population (thousand persons)						
1985	10770.00	3184.23	866.43	331.75	1212.81	5174.78
2000	21580.00	1148.73	810.36	7240.20	1475.87	10904.83

Data source: Migration by reasons (percentage) is obtained from *The 10 Percent Sampling Tabulation on the 1990 Population Census of the People's Republic of China* and *The Tabulation on the 2000 Population Census of the People's Republic of China*. Migration reasons include migration due to job transfer, job assignment, work or business, study and training, to relative and friend, retired or resigned (1985 data only), moved with family, marriage, pull down and move (2000 data only) and other reasons. We categorize migration due to job transfer, job assignment and work or business as work-based migration, and migration due to study or training as migration via *zhaosheng*. Note: There is no available national-wide survey on population outflow (rural-urban migration) in China. Thus, we use changes in urban population as a proxy for population outflow. In the table, numbers of migrant population by reasons is computed based on the proxy for population outflow.

Table 2: *Zhaosheng* flow and the probability of work-based migration

	Zhaosheng flow	Prob. of work-based migration
Regime 1	0.00058946	0.003554486
Regime 2	0.00114381	0.008281515

Source: Authors' calculation using the average of 1985 and 2000 migration reasons in Table 1.

Table 3: Calibration

	Parameter values		Target	Target values		Explanation/Source
	Regime 1	Regime 2		Regime 1	Regime 2	
Preset						
γ_L	0	0.05				preset
δ_{HH}	1	1				preset
Calibrated: Regime-common						
β	0.7798					annual discount factor=1%
ε	1.5					elasticity of intertemporal substitution=2/3
z_{min}	1					standard setup in the literature
ϕ	0.174	0.174				percentage of rural income. Zhu and Zhang (1996)
θ	2.5					computed using rural household net income data in CHIPS 1995 and 2002
ρ	0.6667					elasticity of substitution between high/low skilled=3
α	0.8461		Y_U/Y	0.6922		Bai and Qian (2010)
ψ	0.0618		Y_U/Y		0.8294	Bai and Qian (2010)
Calibrated: Regime-specific						
γ	-	0.9209				urban employment rate, using data in CHIPS 1995, 2002 and 2008
γ_H	1	0.8709				$\gamma_H = \gamma - \gamma_L$
π	0.0036	0.0083				prob. of work-based migration in Table 2
δ_{LL}	0.9996	0.9883	N_H/N_L	0.0424	0.1466	see Appendix C for the detail
B	0.3685	0.7177				$w_R = 1$ in 2007, see Appendix C for the detail
h	1.3529	1.5928				Mincerian rate of return, see Appendix C for the detail
A	5.3877	11.0573	w_L/w_R	1.7781	2.0076	see Appendix C for the detail
τ	7.1103	5.4763	$w_H h/w_L$	1.2296	1.6576	Lee (1999), Zhang et al. (2005) and Ge and Yang (2014); see Appendix C for the detail
$\hat{z}$	17.7632	13.1391		0.059%	0.114%	match regime average of *zhaosheng* flow in Table 2
σ_e	0.1841	0.1021				percentage of rural household income, according to He and Dong (2007)
σ_w	0.5554	0.3079				percentage of rural household income, using data in CHIPS 2002
a	1.1489	0.4701				solved by the indifference boundary equations
b	0.0048	0.0528				percentage of rural household income, using data in UHS 2007 and 2008
Model implications						
$1-G(\hat{z})$	0.075%	0.160%				*zhaosheng* proportion
A/B	14.6188	15.4071				urban-rural TFP ratio
ψ_{cost}	0.6459	0.4380				unit cost reduced by ψ
A_g		5.47%				average annual growth rate of A in 1981-2007
$(A/B)_g$		0.39%				average annual growth rate of A/B in 1981-2007

Note: Calibrated results are not sensitive to the value of γ_L. α, ψ, A and τ are actually solved together to match the corresponding targets listed in the table.

Table 4: Benchmark model

Period	Total output per capita Y/N	Urban output Y_U/Y	Urban employment $(N_H+N_L)/N$	High-skilled employment share $N_H/(N_H+N_L)$	Skill premium $(w_H h/w_L)$
Whole: 1981-2007	1.6206	0.7148	0.2516	0.0784	1.4571
Regime 1: 1981-1994	0.8811	0.6585	0.2174	0.0327	1.2575
Regime 2: 1995-2007	2.4169	0.7754	0.2883	0.1277	1.6720

Table 5: Decomposition - migration channels

Unit: Percentage change

Period	Total output per capita Y/N	Urban output Y_U/Y	Urban employment $(N_H+N_L)/N$	High-skilled employment share $N_H/(N_H+N_L)$	Skill premium $(w_H h/w_L)$
Zhaosheng					
Whole: 1981-2007	6.3%	1.9%	2.8%	30.8%	-3.1%
Regime 1: 1981-1994	2.0%	1.0%	1.1%	30.6%	-1.2%
Regime 2: 1995-2007	8.0%	2.8%	4.2%	30.8%	-4.7%
Work-based migration					
Whole: 1981-2007	4.5%	3.3%	19.9%	-21.7%	7.2%
Regime 1: 1981-1994	0.8%	1.7%	9.7%	-11.5%	3.5%
Regime 2: 1995-2007	5.9%	4.8%	28.1%	-24.5%	10.2%
Interactive migration					
Whole: 1981-2007	0.1%	0.4%	0.2%	11.0%	0.1%
Regime 1: 1981-1994	0.0%	0.0%	0.0%	4.4%	0.1%
Regime 2: 1995-2007	0.2%	0.7%	0.4%	12.8%	0.2%
Non-migration factors					
Whole: 1981-2007	89.1%	94.4%	77.1%	79.9%	95.8%
Regime 1: 1981-1994	97.3%	97.3%	89.2%	76.5%	97.6%
Regime 2: 1995-2007	85.8%	91.8%	67.2%	80.8%	94.3%

Note: Numbers reported in the table are the percentage changes relative to the benchmark model. For example, total output per capita is 1.6206 for the whole period in the benchmark model and 1.5178 in the scenario with the channel of work-based migration only. Therefore, the channel of *zhaosheng* explains 6.3% of total output per capita in the benchmark model.

Table 6: Factor decomposition in regime 2

Unit: Percentage change

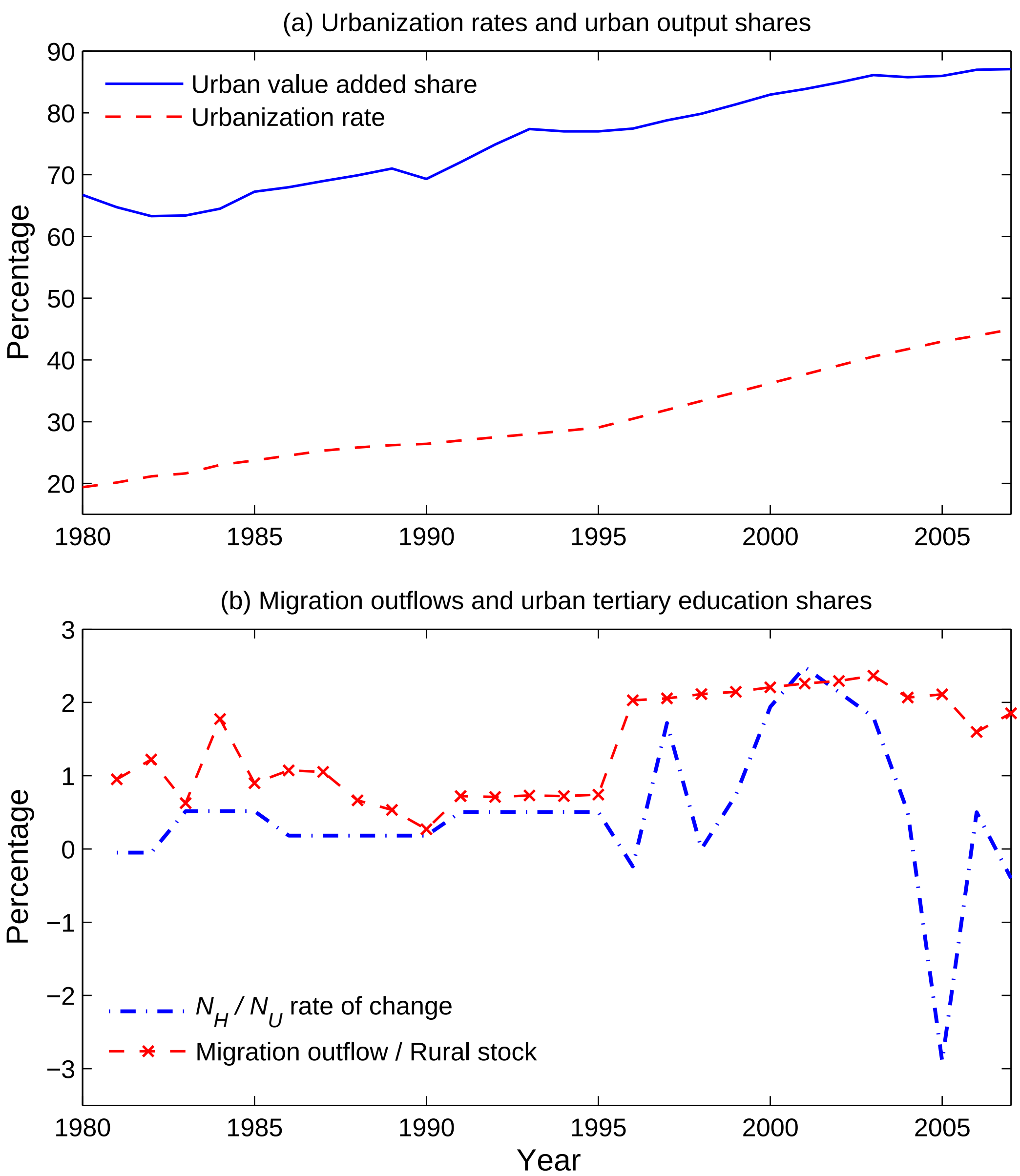
Factors	Total output per capita Y/N	Urban output Y_U/Y	Urban employment $(N_H+N_L)/N$	High-skilled employment share $N_H/(N_H+N_L)$	Skill premium $(w_H h/w_L)$
Abolishment of the GJA (lower γ_H)	-0.9%	-0.2%	-0.4%	-2.9%	0.4%
Better work-based job opportunities (higher π)	1.5%	1.2%	8.2%	-7.3%	2.9%
An increase in the absolute value of education-based migration cost	-0.3%	-0.1%	-0.1%	-0.8%	0.1%
An increase in the absolute value of work-based migration cost	0.0%	0.0%	0.0%	0.0%	-0.0%
Increases in urban and rural TFP	52.9%	1.8%	1.0%	5.5%	-0.8%
An improvement in human capital (higher h)	10.8%	3.0%	0.3%	2.1%	9.8%
An increase in the absolute value of child rearing cost	-1.1%	-0.3%	-0.5%	-3.2%	0.5%
Lower market distortion (lower τ)	1.2%	0.3%	0.6%	3.5%	21.4%
Better intergenerational mobility (lower δ_{LL})	12.3%	3.2%	-0.0%	49.3%	-9.9%
Rising admission selectivity (lower a)	-24.8%	-4.9%	-12.4%	-64.2%	8.5%
An increase in college tuition (higher b)	-2.0%	-0.5%	-1.0%	-6.1%	0.9%

Table 7: Policy experiments

Unit: Percentage change

Period	Total output per capita Y/N	Urban output Y_U/Y	Urban employment $(N_H+N_L)/N$	High-skilled employment share $N_H/(N_H+N_L)$	Skill premium $(w_H h/w_L)$
No GJA in regime 1					
Whole: 1981-2007	-1.2%	-0.4%	-0.5%	-7.0%	0.7%
Regime 1: 1981-1994	-0.7%	-0.3%	-0.3%	-10.0%	0.4%
Regime 2: 1995-2007	-1.4%	-0.5%	-0.7%	-6.1%	0.9%
Better job oppertunities in regime 1: $\pi_1 = \pi_2$					
Whole: 1981-2007	2.8%	2.5%	14.4%	-6.6%	4.2%
Regime 1: 1981-1994	0.9%	2.2%	12.5%	-11.1%	4.1%
Regime 2: 1995-2007	3.6%	2.7%	16.0%	-5.4%	4.2%

Figure 1: Urbanization process in China over 1980-2007



Note: Urbanization rate is defined as urban population shares out of total population. Urban output shares are computed based on Bai and Qian (2010), excluding the agricultural sector. The series N_H/N_U rate of change refers to the changes in the urban tertiary education employment shares. Because there is no good data on migration, we use changes in urbanization as a proxy for migration outflow.

Figure 2: Timeline of the model

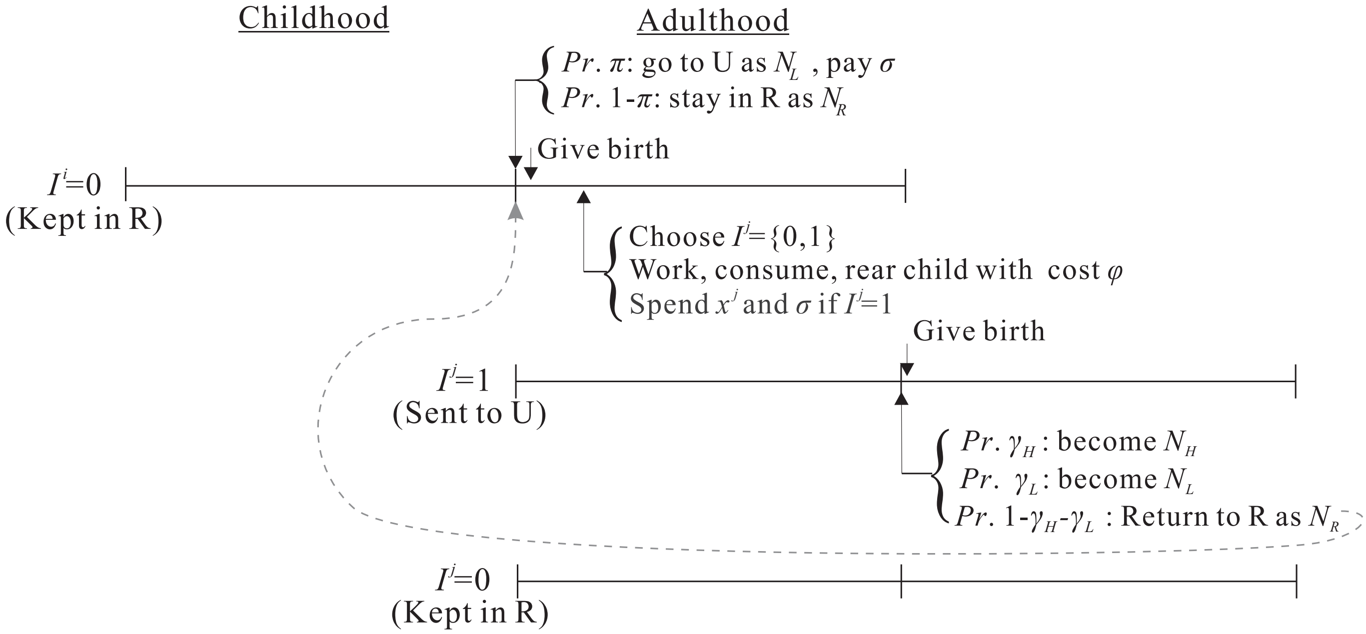


Figure 3: High- and low-skilled wages and rural wage rate

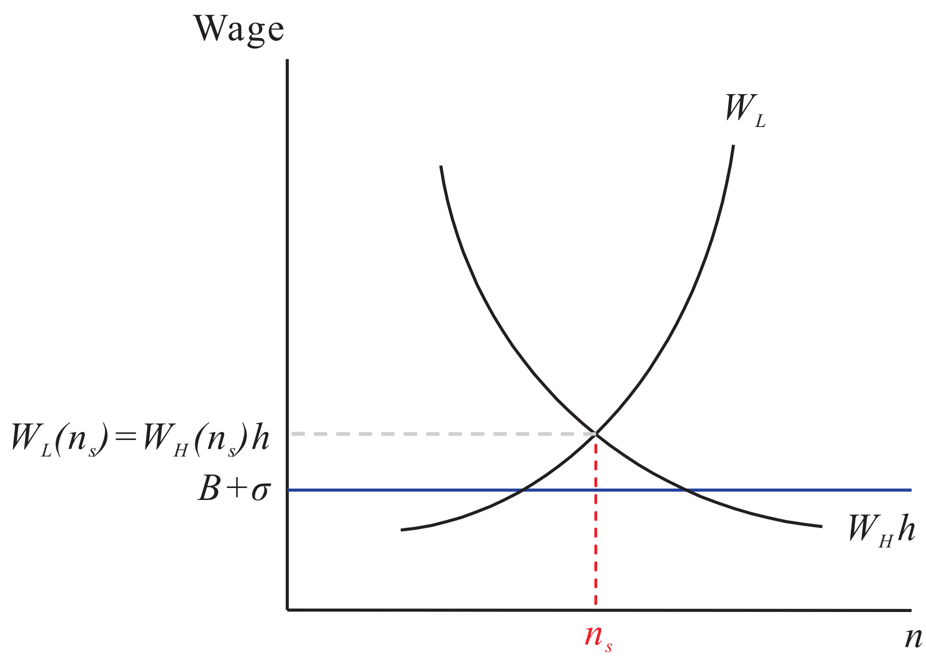


Figure 4: Flows of workers

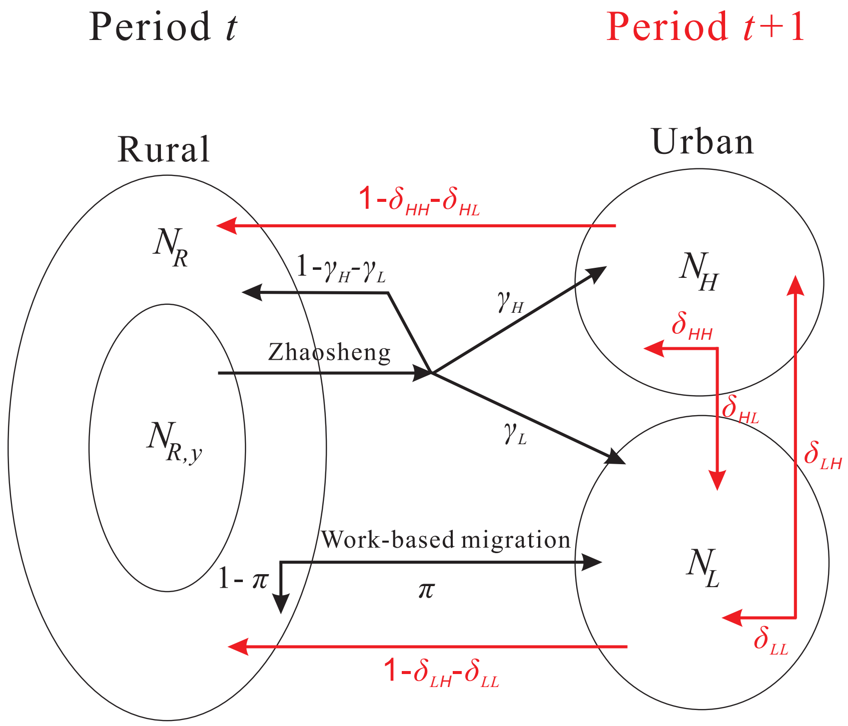


Figure 5: Calibrated urban and rural TFP during 1981-2007

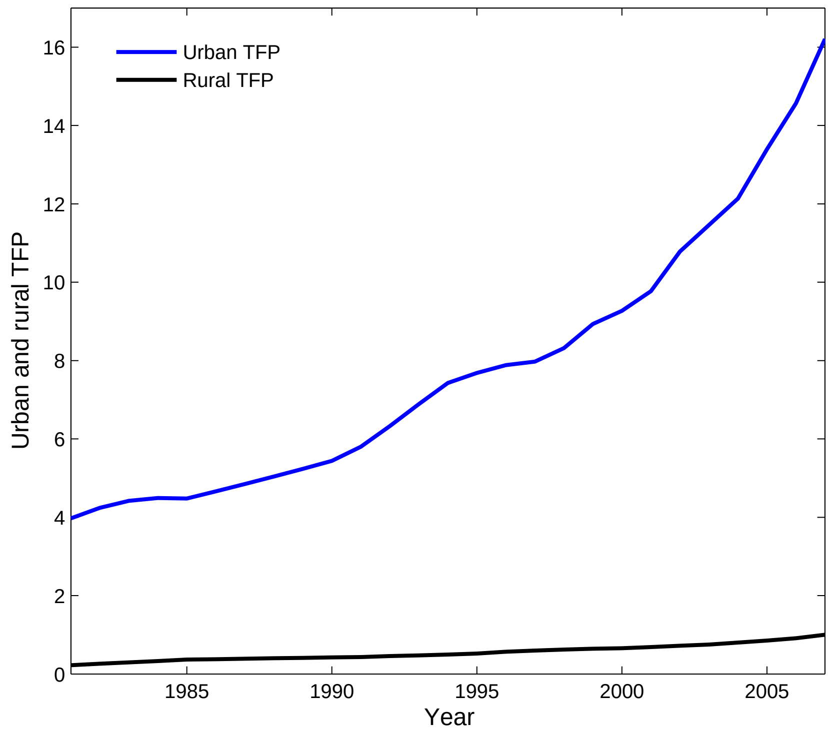


Figure 6: Benchmark model - output

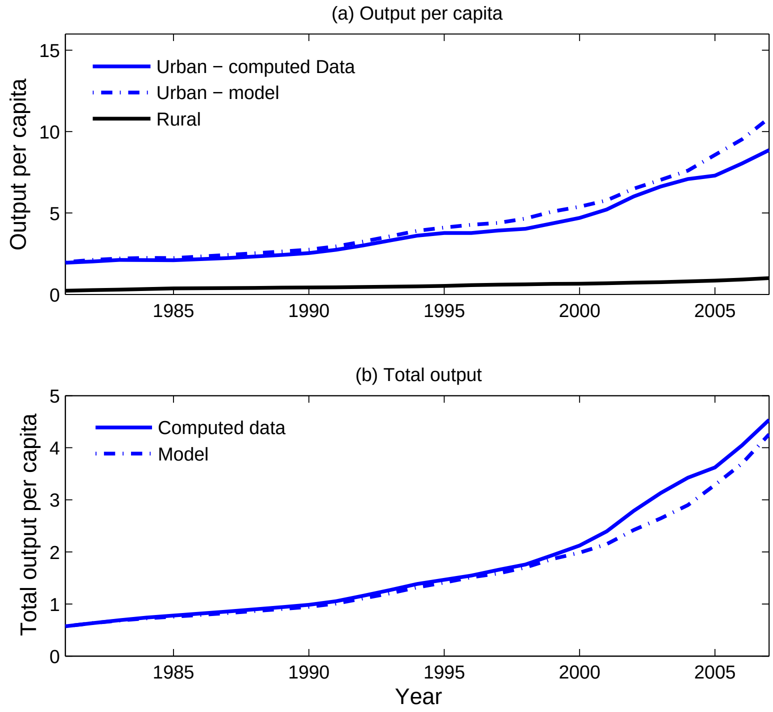


Figure 7: Benchmark model - urbanization rate and labor share

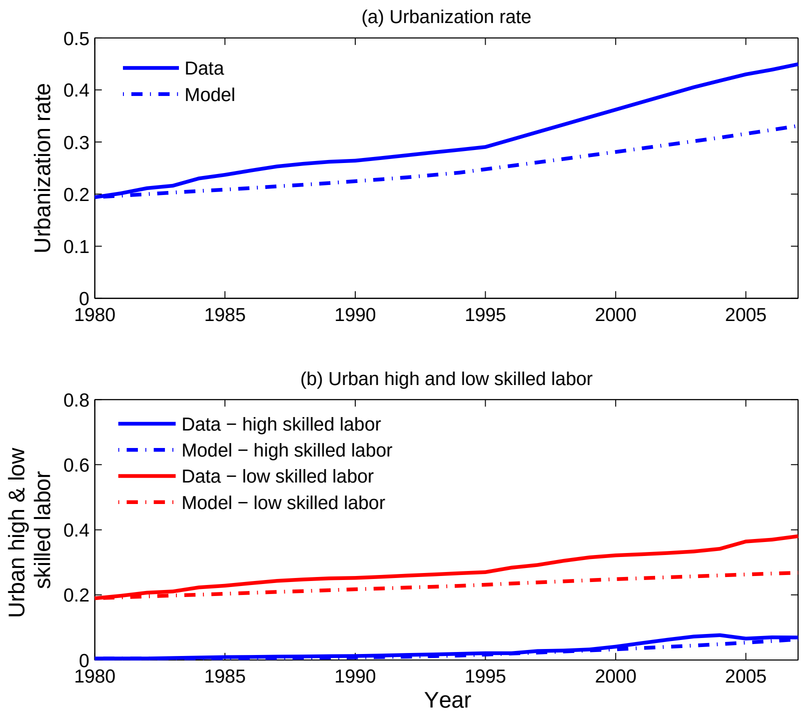
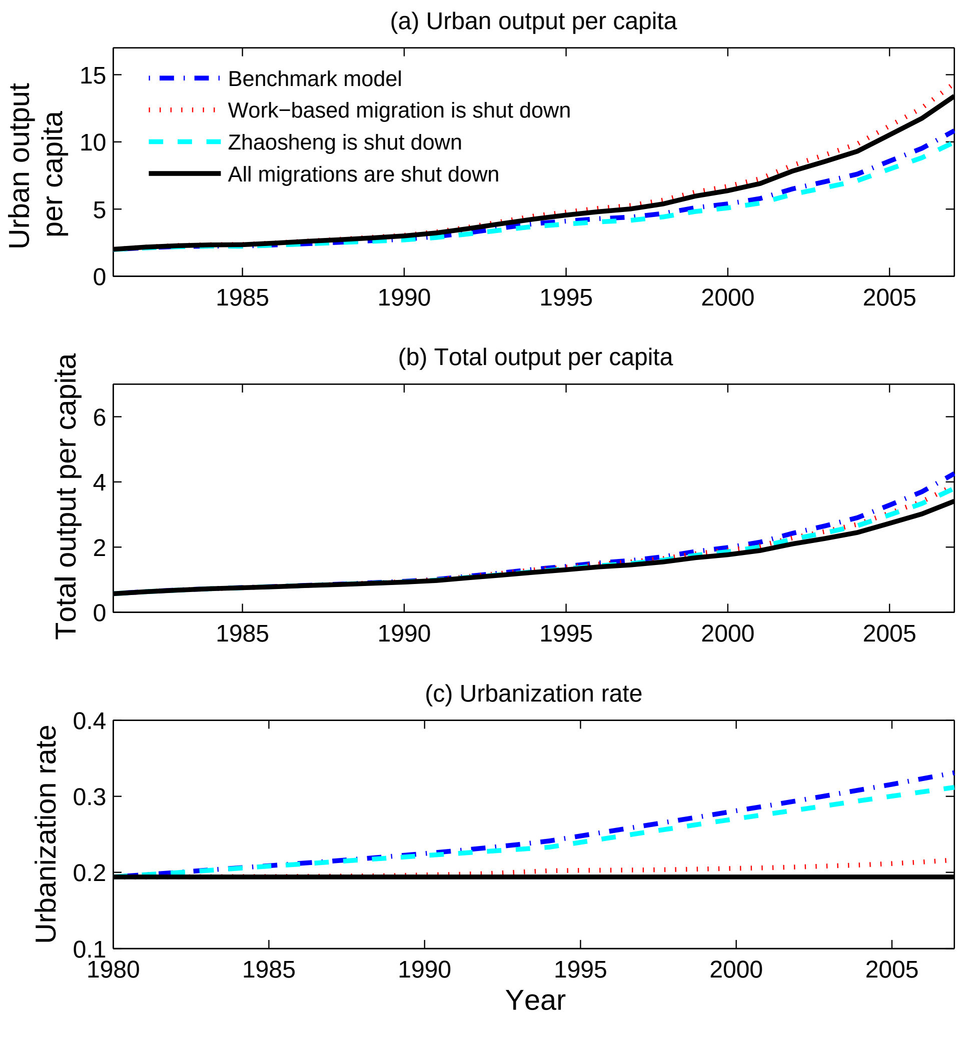


Figure 8: Decomposition for migration channels



Appendix (Not Intended for Publication)

Appendix A: The *Hukou* System and Its Reforms

China implemented the *hukou* system in 1958 to solve a serious problem of the so-called "blind flows" (of rural workers into cities) in the early 1950s. Here, we provide an overview of the *hukou* system and its reforms.

A.1 The *hukou* system

In the main text, whenever we mention that a person holds a formal urban *hukou*, we mean that the person has the right to permanently reside in a city and has full access to all urban benefits. However, in China, a citizen's *hukou* actually contained two parts: *Hukou suozaidi* (the place of *hukou* registration) and *Hukou leibie* (the type of *hukou* registration: "agricultural" and "non-agricultural"). *Hukou suozaidi* was a person's presumed regular residence, such as cities, towns, villages or state farms. Everyone was required to register in one and only one place of residence. This determined the place where the person received benefits and social welfare. *Hukou leibie* was mainly used to determine a person's entitlements to state-subsidized food grain (commodity grain). A citizen with "non-agricultural" *hukou* status would lose the right to rent land and the right to inherit the land that his parents rented. The above two classifications were different. Urban areas contained both agricultural and non-agricultural *hukou* populations. People with non-agricultural *hukou* may live in both urban and rural areas. Therefore, a "formal urban *hukou* holder" in the main text refers to an urban, non-agricultural *hukou* holder. Before 1997, *hukou* registration place and type were inherited from a person's mother. Since 1997, they can be inherited from a person's mother or father.

Under the *hukou* system, *nongzhuanfei*, changing from agriculture to non-agriculture, was the only method to obtain an official urban *hukou*. The regular channels of *nongzhuanfei* included (i) recruitment by a state-owned enterprise (*zhaogong*), (ii) promotion to a senior administrative job (*zhaogan*) and (iii) enrolment in an institution of higher education (*zhaosheng*). Official rural-urban migration involved both changes in *hukou* registration place and in registration type. To complete the *nongzhuanfei* process, a person had to satisfy both the migration requirements and obtain a quota, which was controlled by the central government at approximately 0.15–0.2 per cent of the non-agricultural *hukou* population in each area.

The power of China's *hukou* system did not come from the regulation of migration itself. Rather, its power came from integration with other social and economic controls. In rural areas, governed under the commune system, all rural residents in communes had to participate in agricultural production to receive food rations for their households. In urban areas, there were few jobs outside the state-owned enterprises, and most recruitment and job transfers were controlled by state governments. It was difficult to obtain a job without urban *hukou*. In addition, *danwei* was the basic administrative unit for most citizens with urban *hukou*. It assigned social services for its employees, such as the access to good jobs, grain rations, education for children, health benefits, and rights to purchase a house. Without an administrative unit, it was difficult to survive in cities. Therefore, before the economic reform, people in China lost their freedom of migration.

A.2 *Hukou* reforms

In the late 1970s, the economic reform relaxed administrative controls, such as the abolition of the commune system, the introduction of the household responsibility system and the erosion of the *danwei*-based rationing system. Moreover, the growing market-oriented economy demanded more cheap labour. Therefore, people found it easier to find a job and survive outside of their *hukou* registration place. Both push and pull factors increased informal rural-urban migration (i.e., actually worked and lived outside of their *hukou* registration place). This increase in mobility resulted in a series of *hukou* reforms since 1980.

The interesting part of the *hukou* reforms was the relaxation of migration regulations for the general public. For example, state governments implemented a new type of urban *hukou* with "self-supplied food grain" in 1984. In addition, due to the demands of economic development, several state governments introduced the blue-stamp urban *hukou* in the early 1990s to attract professional workers and investors. The blue-stamp *hukou* required an urban infrastructure construction fee for any newcomer, ranging from a few thousand to some fifty thousand yuan. It allowed people to obtain a temporary urban *hukou*. However, the blue-stamp *hukou* was different from the official urban *hukou* obtained through *nongzhuanfei* in that it provided limited rights and obligations and was only valid in that city. The blue-stamp *hukou* could be upgraded to an official urban *hukou* under certain conditions and after some years.

In 2005, the deputy minister of public security stated that eleven provinces had begun or would soon begin to implement a unified urban-rural household registration system, removing the distinctions between agricultural and non-agricultural *hukou* types. An updated statement in 2007 repeated the same points and included a list of twelve provincial-level units. In the statement of 2014, the government further adjusted migration policies according to the size of a city. The ultimate aim is to establish a unified *hukou* registration system, abolish the regulations of migration and provide social benefits to all residents.

Appendix B: Mathematical appendix

Proof of Proposition 1.

Denote c_U^j as the consumption of children if they are sent to an urban area and c_R^j as the consumption of children if they are kept in a rural area. From (10) and (11) we have:

$$\begin{aligned} c_U^j &= \gamma_H w_H h + \gamma_L w_L + (1-\gamma_H-\gamma_L) w_R - \mathbf{I}^k(X)(1-\gamma_H-\gamma_L)(X+\sigma) - \phi^j, && (23) \\ c_R^j &= (1-\pi) w_R + \pi (w_L - \sigma) - \mathbf{I}^k(X)(X+\sigma) - \phi^j. && (24) \end{aligned}$$

By subtracting (24) from (23) and rearranging terms, under Condition S, we have:

$$\begin{aligned} c_U^j - c_R^j &= \gamma_H w_H h + \gamma_L w_L + (\pi-\gamma_H-\gamma_L) w_R + \mathbf{I}^k(X)(\gamma_H+\gamma_L)(X+\sigma) - \pi(w_L-\sigma) \\ &= \gamma_H w_H h + \gamma_L w_L - \pi w_L + (\pi-\gamma_H-\gamma_L) w_R + \mathbf{I}^k(X)(\gamma_H+\gamma_L)(X+\sigma) + \pi\sigma \\ &> (\gamma_H+\gamma_L-\pi)[w_L(n_s) - w_R] + \mathbf{I}^k(X)(\gamma_H+\gamma_L)(X+\sigma) + \pi\sigma \\ &> 0. \end{aligned}$$

Because $u(\cdot)$ is strictly increasing and strictly concave, we have:

$$u\left(c_U^j\right) > u\left(c_R^j\right).$$

Thus, Assumption 1 and Condition S together guarantee that $\mathbb{E}_X\left(u\left(c_U^j\right) - u\left(c_R^j\right)\right) > 0$ for all $x^k \in (0, x_{\max}]$. ■

Proof of Proposition 2.

Denote $u_{c_U}^j = u_c\left(c_U^j\right)$ as the marginal utility. We compute:

$$\begin{aligned} \frac{d\Delta^i\left(\mathbf{I}^k, x^j\right)}{dx^j} &= -u_{c_U}^j < 0 \\ \frac{d\Delta^i\left(\mathbf{I}^k, x^j\right)}{d\gamma_H} &= \beta\mathbb{E}_X\left\{u_{c_U}^j\left[(w_H-w_R) + \mathbf{I}^k(X)(X+\sigma)\right]\right\} > 0 \\ \frac{d\Delta^i\left(\mathbf{I}^k, x^j\right)}{d\gamma_L} &= \beta\mathbb{E}_X\left\{u_{c_U}^j\left[(w_L-w_R) + \mathbf{I}^k(X)(X+\sigma)\right]\right\} > 0 \\ \frac{d\Delta^i\left(\mathbf{I}^k, x^j\right)}{d\pi} &= \beta\mathbb{E}_X u_{c_R}^j\left[w_R - (w_L-\sigma) - \mathbf{I}^k(X)(X+\sigma)\right] < 0. \end{aligned}$$

Since x^j is decreasing in a and z^j, but increasing in b, the results follow.■

Proof of Proposition 3.

Under Condition S, $c_U^j > c_R^j$ and $u_{c_U}^j < u_{c_R}^j$. Define $\Lambda \equiv u_{c_U}^j (1-\gamma_H-\gamma_L)\mathbf{I}^k(X) - u_{c_R}^j \left[\pi + (1-\pi)\mathbf{I}^k(X)\right]$, then we have:

$$\begin{aligned}
\Lambda &\equiv u_{c_U}^j (1-\gamma_H-\gamma_L)\mathbf{I}^k(X) - u_{c_R}^j \left[\pi + (1-\pi)\mathbf{I}^k(X)\right] \\
&< u_{c_U}^j (1-\gamma_H-\gamma_L)\mathbf{I}^k(X) - u_{c_U}^j \left[\pi + (1-\pi)\mathbf{I}^k(X)\right] \\
&= -u_{c_U}^j \pi + u_{c_U}^j \underset{(-)}{(\pi-\gamma_H-\gamma_L)}\mathbf{I}^k(X) \\
&< 0.
\end{aligned}$$

Therefore, if $-\beta \mathbb{E}_X \Lambda > u_{c_U}^i$, $\frac{d\Delta^i(\mathbf{I}^k, x^j)}{d\sigma} > 0$. ■

Appendix C: Data sources and data computation

1. Population

(1) Rural and urban population

Table 1-4 of the *China Population and Employment Statistical Yearbook* 2010 reported the fraction of rural (urban) population as a percentage of total population in China during the 1952–2009 period. We directly borrow the time series data from 1980 to 2007 for our rural and urban population (N_R and N_U) data. The data in the calibration for regime 1 are the simple average of 1980–1994; for regime 2, the simple average of 1995–2007.

(2) High-skilled and low-skilled workers

The *China Labour Statistical Yearbook* reported the educational attainment composition of urban employment (as a percentage of total urban employment). Thus, workers whose educational attainment is categorized as college and above are defined as high-skilled workers. However, urban data are only available for 2002–2007. Thus, we first use 2002–2007 data to compute an urban to national ratio (a ratio of educational attainment composition of urban employment to that of the entire country). The ratio is approximately 2.457. Second, for the years 1982, 1990, 1995–1999, and 2001, the fraction of high-skilled workers as a percentage of total urban employment is computed using nationwide data and is adjusted by the urban to nationwide ratio. The national data for 1996–1999 and 2001–2007 are also from the *China Labour Statistical Yearbook.* The data for 1982 are from *1 Percent Sampling Tabulation on the 1982 Population Census of the People's Republic of*

China. The data for 1990 are from the *China Population Statistical Yearbook* 1994. The data for 1995 are available in *1995 China 1% Population Sampling Survey Data.* For the years 1980, 1985, and 2000, the educational attainment for total population in Barro and Lee (2001) is adjusted by the urban to nationwide ratio to obtain N_H/N_U. Third, we interpolate data for the years for which no data are available. Finally, the fraction of high-skilled workers as a percentage of total urban employment is multiplied by N_U to obtain N_H. Then, N_L is the difference between N_U and N_H. The data in the calibration for regime 1 reflect the simple average of 1980–1994, and for regime 2, the average is for 1995–2007.

(3) Rural to urban migration flows

There is no available nationwide survey on rural to urban migration for the periods of China that we examine. Here, we use changes in urban population as a proxy for total rural to urban migrants. We are aware that changes in urban population is equal to the amount of rural-urban migrants only if births and deaths in urban areas are net out exactly. However, as shown in Table C.1, we find that the net birth rates in urban and rural areas are quite stable during the periods that we examine. Since there is no nationwide available data on rural-urban migration, we use changes in urban population as a proxy. In addition, we believe that the actual rural-urban migration could be larger than our proxy because the birth rates and mortality rates are both higher in rural areas than those in urban areas.

The total number of rural to urban migrants is then divided by the stock of rural population to obtain the flow of migrants (as a percentage of the rural population). In the calibration, we take the simple average on the flow of migrants for 1981–1994 to be the flow of migrants in the first regime. The second regime is the average of the 1995–2007 flows. Finally, the average flows of migrants are multiplied by the working-related and studying or training reasons (the average of 1985 and 2000) to obtain the probabilities of working migration and *zhaosheng* flow, respectively.

(4) Migration reasons

The *10 Percent Sampling Tabulation on the 1990 Population Census of the People's Republic of China* reported the number of immigrants by type of usual residence and cause of migration for 1985. We choose "the number of immigrants from town and county of this province" and "the number of immigrants from town and county of other provinces" to be rural to urban migration in 1985. Then, the fraction of migrants due to each reason as a percentage of total rural to urban migration is computed. The *Tabulation on the 2000 Population Census of the People's Republic* *of China* only reported the number of emigrants and the reasons for emigration. We thus choose the number of emigrants from towns and counties to represent rural to urban migration in 2000. Then, the fraction of migrants for each reason as a percentage of total rural to urban migration is computed. Finally, we categorize migration due to job transfers, job assignments, and work or business as working-related reasons. The migration due to studying or training is categorized as migration via *zhaosheng*.

2. Human capital

Table C.2 summarizes average years of schooling for the group of college and above and the group of less than college. The urban employment by education in 1995 data are from the *China Statistical Yearbook* 1998. The 2002 and 2009 data are from the *China Labour Statistical Yearbook* 2002 and 2009, respectively. We further assume that the years of schooling for graduate school is equal to 18 years, 16 years for college, 14 years for junior college, 12 years for senior high, 9 years for junior high, 6 years for primary school, and 1 year for semi-illiterate or illiterate. Then, weighted average years of schooling for college and above and less than college are computed. Table C.3 provides the average years of schooling for 1981, 1988, 1995, and 2002. For years without data, they are computed by backward extrapolation based on 1995, 2002, and 2009 data. In the calibration, years of schooling in regime 1 (8.02 and 14.10) is the average of 1981 and 1988 and regime 2 (8.95 and 14.52) is the average of 1995 and 2002.

To compute the human capital possessed by high-skilled workers relative to low-skilled workers, the Mincerian method is employed. The education returns coefficients in China reported by Zhang et al. (2005) are 0.0479 and 0.0835 for 1980–1994 and 1995–2007, respectively. Thus, the human capital in regime 1 is equal to $\frac{e^{0.0479*14.1}}{e^{0.0479*8.02}}$. The human capital in regime 2 is $\frac{e^{0.0835*14.52}}{e^{0.0835*8.95}}$.

3. Urban employment rate

In the model, $\gamma_H + \gamma_L$ refers to the employment rate of college graduates who migrated from rural areas. However, no data are available. Thus, we use the urban employment rate as a proxy. Urban employment rate is computed by using the number of urban working or employed workers divided by the sum of the number of urban working or employed workers and the number of workers who are waiting for a job or unemployed. The urban employment rate of 1995 is computed using 1995 CHIP urban individual data; the value of 2002 is computed using 2002 CHIP urban individual income, consumption, and employment data; and the value of 2007 is computed using 2007 CHIP (or RUMiC 2008). The average of them is the urban employment rate in the calibration.

4. Labour income shares

Bai and Qian (2010) reported the sectoral labour share of GDP for the 1978–2004 period and the sectoral composition of value-added at factor cost in China. We thus compute a time series of labour income share in urban areas by assuming that industry, construction, and service belong to the urban sector. The labour income share is weighted by the corresponding sectoral composition of value-added at factor cost. In the calibration, the labour income share is the average of 1980–1994 in regime 1 and of 1995–2004 in regime 2.

5. Rural per capita income

The *China Statistical Yearbook* 2011 reported rural real per capita income from 1978 to 2011. However, during the period before 1990, only data for 1978, 1980, and 1985 are available. We thus use interpolation to compute rural real income per capita for 1981–1984 and 1986–1989. Then, the rural real income per capita of 2007 is normalized to one. The rural real income per capita for other years is adjusted accordingly. In the calibration, the rural income of regime 1 is the average of rural real income per capita during the 1980–1994 period. The rural income of regime 2 is the average of 1995–2007.

6. Skill premium

Zhang et al. (2005) estimate the skill premium for China during the 1988–2001 period, while Ge and Yang (2014) estimate it for 1992–2007. Using the ratio of the skill premium in Zhang et al. (2005) to that in Ge and Yang (2014), we construct a time series for the skill premium for 1988–2007 based on Zhang et al. (2005). Furthermore, Lee (1999) estimates the skill premium for China in 1980 and 1988. However, the estimate in Lee (1999) is higher than that reported by others because the estimate is based on a survey of SOEs. Therefore, we first compute the growth rate of the skill premium from 1980 to 1988 in Lee (1999). Then, using the estimate of the skill premium in 1988 in Zhang et al. (2005) and the growth rate computed from Lee (1999), the skill premium in 1980 is obtained. Finally, curve fitting with polynomial 3 is used to construct a series for the skill premium from 1980 to 2007. In the calibration, the skill premium of regime 1 is the average of 1980–1994. The skill premium of regime 2 is the average of 1995–2007.

7. Urban premium

The urban premium is defined as the ratio of the low-skilled wage to the rural wage. The *China Statistical Yearbook 2011* also reported urban real income per capita for 1978–2011. Thus, we are able to compute a ratio of urban to rural income per capita. Because urban income per capita is a weighted average of the high-skilled wage and the low-skilled wage, we are now able to compute the urban premium using the skill premium data, urban-rural income per capita ratios, and the ratios of high- to low-skilled worker stocks. However, during the period before 1990, data are on

8. Parameter of the Pareto distribution θ

Chinese Household Income Project (CHIP) 1995 and 2002 reports rural household net income data. We first compute the mean of the rural household net income for each year. Then the rural household net income is divided by the average number of rural household members to obtain the average of rural individual income. Similarly, we compute the standard deviation and the variance of the rural individual income. Finally, using the formulas for the mean and variance of Pareto distribution, we are able to back out the value of θ, which is roughly equal to 2.5138 for 1991-2002. We thus set θ to 2.5. The average number of rural household members is roughly equal to 4. The data is also from CHIP 1995 and 2002.

9. Work-based migration cost

CHIP 2002 rural-urban migrant individual data provides information on the expenditures occurred in the first month when migrant workers arrived at the city. In the calculation of the work-based migration cost, food and housing costs are counted as regular costs, while city expansion fee, certification fee and others are considered as one-time cost. Our work-based migration cost is thus the sum of the above costs, adjusted for model periods and expressed as a percentage of rural household income. Rural household income is computed by multiplying rural real per capita income by the average number of rural household members. Rural real per capita income is obtained from the *China Statistical Yearbook* 2011 and the average number of rural household members is from the *China Rural Statistical Yearbook*.

10. Computed data in figures

(1) Urban output

The computed data for urban output is calculated by the urban production function. Using the calibrated parameters, the calibrated time series of urban TFP, the time series data of high-skilled workers, and the time series data of low-skilled workers, we are able to obtain the computed data for urban output. The computed data for urban per capita output is the computed data for urban output divided by the time series data for high- and low-skilled workers.

(2) Rural output

The computed data for rural output is obtained from the rural production function. Because we have time series data of rural per capita income (2007 is normalized to one) and the stock of the rural population, we are able to obtain the computed data for rural output.

(3) Total output

The computed total output is the sum of the computed data for urban output and rural output.

Table C.1: Net birth rates in China

Unit: ‰

Year	Urban areas Birth rate	Urban areas Mortality rate	Urban areas Net birth rate	Rural areas Birth rate	Rural areas Mortality rate	Rural areas Net birth rate
1980	14.17	5.48	8.69	18.82	6.47	12.35
1981	16.45	5.14	11.31	21.55	6.53	15.02
1982	18.24	5.28	12.96	21.97	7.00	14.97
1983	15.99	5.92	10.07	19.89	7.69	12.20
1984	15.00	5.86	9.14	17.90	6.73	11.17
1985	14.02	5.96	8.06	19.17	6.66	12.51
1986	17.39	5.75	11.64	21.94	6.74	15.20
1987	-	-	-	-	-	-
1988	-	-	-	-	-	-
1989	16.73	5.78	10.95	23.27	6.81	16.46
1990	16.14	5.71	10.43	22.80	7.01	15.79
1991	15.49	5.50	9.99	21.17	7.13	14.04
1992	15.47	5.77	9.70	19.09	6.91	12.18
1993	15.37	5.99	9.38	19.06	6.89	12.17
1994	15.13	5.53	9.60	18.84	6.80	12.04
1995	14.76	5.53	9.23	18.08	6.99	11.09
1996	14.47	5.65	8.82	18.02	6.94	11.08
1997	14.52	5.58	8.94	17.43	6.90	10.53
1998	13.67	5.31	8.36	17.05	7.01	10.04
1999	13.18	5.51	7.67	16.13	6.88	9.25

Source: *China Statistical Yearbook* 1990 and 2000. Data for 1987, 1988, and years after 1999 are not available.

Table C.2: Urban employment by education

Education Attainment	Years of schooling	1995	2002	2009
College or above		10.6%	15.9%	16.2%
Graduate	18		0.3%	0.5%
College	16		4.4%	5.8%
Junior college	14		11.2%	9.9%
Average years of schooling college or above			14.63	14.84
Below college		89.4%	84.1%	83.8%
Senior high	12	24.6%	26.6%	20.7%
Junior high	9	39.7%	41.0%	45.6%
Primary	6	20.4%	13.6%	15.4%
Semi-illiterate or illiterate	1	4.7%	2.9%	2.1%
Average years of schooling below college		8.72	9.19	8.99

Source: *China Statistical Yearbook* and *China Labour Statistical Yearbook*.

Table C.3: Average years of schooling

Year	*Below college*	*College or above*
1981	7.79*	14.00*
1988	8.25*	14.21*
1995	8.72	14.42*
2002	9.19	14.63
Average: 1981-2002	8.49	14.31
Average: 1981 and 1988	8.02	14.10
Average: 1995 and 2002	8.95	14.52

Note: * denotes those numbers are obtained from backward extrapolation using on 1995, 2002 and 2009 data.