Rural-urban Migration and Minimum Wage – A Case Study in China

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Abstract:
In spite of their positive influence on living standards and social inequality, it is commonly agreed that minimum wage laws reduce output because they produce unemployment. This paper suggests that minimum wage policy may be beneficial for a transitional economy in which labor is migrating from rural region to urban region and positive migrating costs occur. With a positive migrating cost, a binding minimum wage can cause relatively low productivity urban workers to be replaced by more productive rural migrants, and therefore increase aggregate output. Moreover, minimum wage policy can be used to affect migration flows and social inequality. The simulation results suggest that minimum wage policy may benefit the whole economy if it is only binding for urban workers but not for migrant workers in the urban industrial sector. Otherwise output is negatively affected. To achieve the second best outcome, governments should fully compensate the migrating costs for the marginal migrant workers who migrate from the rural industrial sector to the urban subsistence sector and a binding minimum wage should be imposed on the urban workers but not the migrant workers in the urban industrial sector.

Keywords: minimum wage, internal migration, selection, inequality, China
JEL classification: J61, O15, O18, O53

1 Introduction
Minimum wage policy has been popularly used in both developed and developing countries, even though it serves different purposes. As pointed out by Watanabe (1976), developed countries intend to the US sector to minimum wages to provide an acceptable living standard for their marginal workers, while developing countries intend to the US sector to adjust their social inequalities. A minimum-wage system was officially introduced in China’s Labor Law in 1994. It stated that the minimum wage should be set to ensure that the lowest wage earned by a worker be sufficient to support her basic needs. The Labor Law was an attempt to protect workers by specifying the form of payment, maximum hours, and overtime rates. In reality, it functioned more like a set of recommendations than binding policy, because there was no solid punishment for firms that did not abide by it. Although the minimum wage increased several times after 1994, the average income of low-skilled workers fell further behind the average urban income. From 1994 to 2004, the average annual income of civil servants in Dongguan City in Guangdong Province increased by as much as 340\%, from 8,000 RMB to more than 35,000 RMB; during the same period, the average wages in the leather and shoe industry stayed between 6,000 RMB to 10,000 RMB, and only

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increased by a total of 71%. The Provisions on Minimum Wages was enacted in 2003 by the Ministry of Labor and Social Security, as an attempt to strengthen the protection of low-skill workers provided by the minimum-wage system. It required that the minimum wage be readjusted at least every two years according to such factors as the cost of basic necessities for employees and their dependents, as well as the local consumer price index. The readjustment was frozen in 2009 due to the worldwide recession. In 2010, following the recovery of China's economy and due to shortages of migrant workers, 30 of China's 31 provinces and municipalities announced increases in their minimum wages, at different rates. For example, Shanghai has China's highest minimum wage at 1120 RMB per month—an increase of 16.7%; in Guangdong province it increased by 21.1%; Hainan province saw the greatest increase at 37%. But these wages are still very low when compared with the local average wage. For example, the average wage in Shanghai was 3759 RMB in 2009, while its minimum wage in 2010 was only 30% of that.

It is commonly agreed that minimum wages increase unemployment and reduce output when workers are homogenous and labor markets are perfectly competitive in the presence of perfect information. Absent these restrictive assumptions, however, many economists draw different conclusions. It has been shown that minimum wages might be Pareto optimal if the labor market is not competitive, or if workers are not homogeneous, or if there is no perfect information. For example, Boal & Ransom (1997), Strobl & Walsh (2007), and Ashenfelter, Farber & Ransom (2010) suggest that minimum wages decrease unemployment in a monopsony market. And Drazen (1986) suggest that, with heterogeneous workers, minimum wage may be Pareto optimal if a higher wage would be preferred to the market clearing wage, even though unemployment is produced. Also, Broadway & Cuff (2001) argued that minimum wage may be optimal because it can be combined with the institutional features of a typical welfare system to fix the government's asymmetric information problem with respect to workers' abilities.

In this paper, we study the effects of minimum wages on a transitional economy, such as China, in which migration flows from rural region to urban region at positive migrating costs. There are three main results from our analysis. First, minimum wage is a useful instrument for the government to control migration flows. Second, regarding social inequality adjustments, a minimum wage leads to improvements in urban region, but to a worsening in both rural region and the country as a whole. Third, a minimum wage may be optimal due to the moving friction: a migrating cost wedge induces a modestly binding minimum wage to cause relatively less productive urban workers to be replaced by more productive rural migrants. To show these results, we first construct a theoretical model, focusing on the selection effects on determining the labor market outcomes, and then compare the outcomes with minimum wages to the status quo ante. Our model indicates that minimum wage policy has different effects on migration flows to formal sector, depending on the level at which it is set. When its value is low, minimum wage induces fewer urban workers but more migrant workers to work in the urban modern industrial sector. However, when its value is high, migrant workers are also constrained from entering the urban industrial sector. The effects on the urban informal sector are unclear. We then calibrate our theoretical model by using data from China to simulate the effects of minimum wages. We begin by calibrating our model's parameters to match labor market outcomes in China

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3 More information can be found in Wages in China, published on China Labor Bulletin on Feb 19th, 2008

4 The information is published on the official website of The Central People's Government of The People's Republic of China.

5 Numbers are quoted from the Shanghai Statistical Yearbook 2010
in 2006. By using 2006 as benchmark, the calibrated model predicts that when the minimum wage is not high enough to constrain qualified rural workers from moving to the urban industry sector, it benefits the whole economy; otherwise, it has negative effects on economic growth. The calibration also predicts worse inequality in rural region but less inequality in urban region, given the same investment profile. To achieve the second best outcome, government shall fully compensate the migrating costs for the marginal migrant workers from the rural industrial sector to the urban subsistence sector, and the minimum wage shall not be binding for migrant workers in the urban industrial sector.

The rest of this paper is organized as follows. Section 2 presents the theoretical model. Section 3 analyzes the effects of minimum wage policy. Section 4 provides calibrations and simulations of our model. Section 5 discusses some potential policy implications. Section 6 concludes, and suggests some potential extensions.

2 Model setup
2.1 Model assumptions
We construct a model with two regions, rural and urban, and four sectors to facilitate internal migration. Each region has two sectors. In rural region, there are an agricultural (RA) sector and an industrial (RM) sector. In urban region, there are a former urban modern industrial (UM) sector and an informal urban subsistence (US) sector. The RM sector is developed with some exogenous physical capital investment, which is significantly less than is invested in urban region. All residents can be identified by a residency registration system. The rural labor force is $L_r$, and the urban labor force is $L_u$, and we assume that $L_r$ is much greater than $L_u$. We also assume that each worker possesses some human capital. Initial levels of human capital are determined by nature, while education and job-training yield significant increases. Each worker has his own human capital, $a_i$, which ranges from 0 to 1. The distributions of human capital in the rural and urban populations are $p^r$ and $p^u$, respectively. Since education resources are allocated more in urban region and there are uneven opportunities to access to post-secondary education, $p^u$ is assumed to exhibit first-order stochastic dominance over $p^r$.

In the RA sector, labor is considered homogenous, and the production function is:

$$y_a = g(N_a)$$

where $N_a$ is total physical labor input. We assume $g' > 0 > g''$. Farmers are paid at their marginal product of labor (MPNs) and the government, as the landowner, takes all the remaining output.

In the industrial sectors, we assume agents work individually and the produce functions are CRTS. Workers are paid their marginal product. Each worker’s production functions in the UM and RM sectors are:

$$y_{im} = f(N, a_i, k_u)$$

$$y_{rm} = h(N, a_i, k_r)$$

where $a_i$ is the human capital possessed by worker $i$, and $N$ is the physical labor input of each worker, which is normalized to 1. Note that we assume total capital investment in both industrial sectors is equally distributed among the workers, $k_u = K_u/L_u$ and $k_r = K_r/L_r$. The marginal product of labor, $MPN_i$, is increasing with $a_i$ and $k$ as capital and labor are complements.

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6 Here human capital is defined as the stock of skill and knowledge embodied in the ability to perform labor, so it can be measured in terms of productivity.
Government allocation of investment between sectors is assumed to be exogenous and $K_u > K_r$. Manufactured goods are homogeneous.

The relative price between agricultural goods and industrial goods, $P$, clears the market. Manufactured goods are defined as the numeraire. The price function is:

$$P = \rho \left( \frac{y_u}{y_m} \right)$$

with $y_m = y_{um} + y_{rm}$ and $\rho(\cdot) < 0$.\(^7\)

### 2.2 The first best and second best outcomes

The first best outcome occurs when all resources are mobile across sectors, and there is thus no difference between urban and rural regions. In the first best case, capital goes to the sector with higher returns between industrial sector and agricultural sector. There is a boundary of human capital in that those workers with higher human capital work in the manufacturing sector and those with lower human capital work in the agricultural sector. Since in our model labor is the only flexible factor and there are many practical constraints, the first best case is not possible in the real world at least in the near future, and thus it will not be discussed in detail.

The second best outcome occurs with only one constraint: that is, capital is predetermined. In the second best case, the difference between urban and rural region exists since investment profiles are quite different. To induce the second best outcome, the migrating costs must be assumed away. If the US sector is assumed to be a channel to reallocate social wealth and produce no real outputs, and the utility functions are based on real outputs only, the second best outcome must satisfy several conditions. First, agents’ utilities are maximized given the outputs of manufactured goods and agricultural goods. Second, workers with the same human capital are treated equally. That is, either they are all in the same sector or they are all out of that sector, since labor is totally mobile. Third, in the second best outcome the marginal products of labor for the same worker must be equalized across the UM and RM sectors, which determines the labor allocation. This may imply a urban-to-rural migration flow to the RM sector if it requires more workers.

Based on our model setup, the second best outcome may be derived in a simple way. Because of the properties of the production functions in modern industry sectors, there are two opposite effects when an extra worker enters. On the one hand, labor increases, contributing positively to total outputs. On the other hand, the extra workers decrease the capital available to each worker, which has a negative effect on output. Therefore the total output may be maximized at a certain cut-off level of human capital. At this cut-off level of human capital, once the ratio between manufacturing goods and agricultural goods exceeds the optimal ratio of subjective demands which is determined by equating the marginal utilities of consuming each good, some workers must switch from the industrial sector to the agricultural sector until the output ratio is optimal. Otherwise, the second-best outcome is induced. Numerical analysis cannot be done without specific assumptions on functional forms. We discuss this further in Section 4.

The equilibrium outcome that we may observe in the real world is the market equilibrium. Besides the constraint imposed on the second best case, the market equilibrium also experiences positive migrating costs. This is the main focus of this paper.

### 2.3 The market equilibrium outcome

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\(^7\) One possible way to endogenize it is to assume homogeneous preference over both agricultural and industrial goods (e.g. Cobb-Douglas). Given a relative price level, the consumption ratio is constant, and should be proportional to the ratio of outputs when the market clears. Thus relative price is negatively related to the ratio of outputs. Please refer to Appendix 2.A.
To determine the market equilibrium outcome, migrating costs must be considered since migrant workers are subject to them in the real world. The costs of migrating to big cities are not just pecuniary, but also include psychological discomfort, such as loneliness, discrimination from urban residents, safety issues, etc. Sjaastad (1962) breaks down the moving cost into money and non-money costs. "The former include the out-of-pocket expenses of movement, while the latter include foregone earnings and the 'psychic' costs of changing one's environment". Zhao (1999) called them "explicit costs" which also include the costs imposed by government and "implicit psychic cost".

When a rural worker considers moving, she compares the benefits of moving to the cost. By assuming that a higher wage is the benefit she would earn if working in an urban area, her net benefit function is:

$$B(a_i) = w(a_i) - C(a_i)$$

we assume that $w_{um}(1) - C(1) - w_{rm}(1) > 0$, i.e.

$$f'_{N}(1, K_u/(L_u \int_{a_u}^{1} p^{u}(a_u) \, da_u) - h'(1, K_r/(L_r \int_{a_r}^{1} p^{r}(a_r) \, da_r)) > 0$$

to make sure that at least the highest ability rural worker obtains a net benefit from moving to the UM sector. Because working in the UM sector yields higher wages, rural workers consider their qualifications for positions in this sector first, given the same migrating cost, if they decide to migrate. Employment in the urban industrial sector is now composed of urban workers and migrant rural workers.

**Proposition 1: The migration flow to the UM sector decreases in the migrating costs and increase in the urban-rural wage difference.**

**Proof.** The rural worker migrating to the UM sector with the least human capital, $a_X$, must be indifferent between the benefits from staying in the rural sector and the wages earned in the UM sector. Employment in the UM sector includes urban workers and migrant workers which are:

$$N_{um} = L_u \int_{a_u}^{1} p^{u}(a_u) \, da_u$$

$$N_{r} = L_r \int_{a_r}^{1} p^{r}(a_r) \, da_r$$

where $a_Z$ is the least human capital of an urban worker who stays in the UM sector. A migrant worker from rural areas with $a_X$ must satisfy:

$$w_{X}^{um} - w_{X}^{rm} = C(a_X)$$

where $w_{X}^{um}$ is the income of the rural migrant worker with $a_X$ who migrates to the UM sector which equals $MPN_{um}(a_X, K_u/(N_X + N_{UM}))$ and $w_{X}^{rm}$ is the income of the same worker who stays in the RM sector which is $MPN_{rm}(a_X, K_r/N_{RM})$ and $N_{RM}$ is the employment in the RM sector:

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8 Sjaastad (1962) breaks down the moving cost into money and non-money costs. "The former include the out-of-pocket expenses of movement, while the latter include foregone earnings and the 'psychic' costs of changing one's environment". Zhao (1999) called them "explicit costs" which also include the costs imposed by government and "implicit psychic cost".

9 The moving cost is also affected by the locations of rural areas, traffic conditions, and other factors, while I focus on the effects of human capital.

10 Zhang and Lei (2008) point out that there are four components in social integration for a Chinese domestic migrant: cultural integration, mental integration, identity integration and economic integration. They also construct an empirical model to test the determinants on social integration by using data on 600 new migrants to Shanghai. The coefficient of schooling years is 0.89 which implies that migrants with higher education levels integrate into a new society faster.
\[ N_{RM} = L \int_{a_m}^{a_x} p^r(a_r) \, da_r \]  
where \( a_M \) is the least human capital possessed by a rural worker who stays in the RM sector. We know that \( C(a_X) > 0 \) and \( C'(a_X) < 0 \) thus the RHS of equation (9) is a decreasing function on \( a_X \). In LHS:
\[
\frac{d(w^m_X)}{d(a_X)} = MPN^{um}_{a_X} + MPN^{um}_{k_u} \cdot \frac{d(k_u)}{d(a_X)}
\]
where \( k_u = K_u / (N_X + N_{UM}) \) and all terms are positive which implies \( w^m_X \) is an increasing function of \( a_X \).
\[
\frac{d(w^{rm}_X)}{d(a_X)} = MPN^{rm}_{a_X} + MPN^{rm}_{k_r} \cdot \frac{d(k_r)}{d(a_X)}
\]
where \( k_r = K_r / N_{RM} \). We have \( MPN^{rm}_{a_X} \) and \( MPN^{rm}_{k_r} \) as positive terms but \( d(k_r) / d(a_X) \) is negative. Therefore \( w^{rm}_X \) may increase or decrease with \( a_X \). But as UM is assumed to always be attractive to high ability workers, \( w^m_X \) increases slower than \( w^{rm}_X \). Therefore the LHS of equation (9) is an increasing function of \( a_X \). Figure 1 depicts the information embodied in equation (9).

![Equilibrium human capital thresholds](image)

Intuitively, institutional and economic barriers increase the cost of migration, and local job options increase the benefit of staying. Thus, they both decrease labor mobility. The equilibrium human capital of the last rural worker who would migrate to the UM sector is \( a_X \), where \( w^{um}_X - w^{rm}_X \) intersects \( C(a_X) \). If there is no RM sector and labor mobility across areas was allowed, \( a_X \) is determined by \( w^{um}_X - w^a = C(a_X) \) which ends up at lower \( a'_X \). In this case, high volume of rural workers would migrate and work in the UM sector. On the other hand, increase in restriction or discrimination against rural migrant workers pushes up the cost curve to \( C'(a_X) \). Consequently more rural workers would stay in rural region.

Not every job seeker is qualified to have a job in the UM sector. Many of them have to work in the US sector. As described in Cole and Sanders (1985), the US sector consists of "those

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\[ a_X \] is the wage earned by farmers which is no higher than \( w^{rm}_X \).
urban employment categories that feature very low levels of productivity and earnings”. The US sector can absorb all labor who wants to work in it, thus there is no unemployment for migrant workers. This is the key difference from Harris and Todaro (1970). All US workers are assumed to be paid at $w_{us}$. Even though $w_{us}$ is less than the wage earned in the UM sector, the fact that people do stay in the city and don’t go back indicates that it is still greater than the potential wage when working in rural areas. The wage difference provides the incentive for some rural workers to migrate to cities, even if only to get a position in the US sector.

**Proposition 2:** There is a lower limit, $a_N \in (0,1)$, and an upper limit, $a_M \in (0,1)$, with $a_M > a_N$, on human capital with which rural workers migrate to the US sector. Only the rural workers with human capital between $a_N$ and $a_M$ migrate to the US sector.

**Proof.** Rural workers heading to the US sector must satisfy the following condition:

$$w_{us} \geq w_r + C(a_i) \tag{11}$$

where $w_{us}$ and $C(a_i)$ are defined the same as before, and $w_r$ is the wage when staying in rural region. It may be the wage from either the RA or RM sector, because either farmer or worker, or both, may consider moving to the US sector. But because $w_{us}$ is the lowest wage for the workers in the UM sector, only those who cannot go to the UM sector will think about going to the US sector.

Because $C(a_i)$ is a decreasing function of human capital, $w_r$ is a non-decreasing function of human capital and $w_{us}$ is the same for every worker in the US sector, Figure 2 illustrates the situation in which rural workers would migrate to the US sector.\(^{12}\)

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**Figure 2  Heading to the US sector**

Figure 2c shows that there exists an upper limit, $a_M$, and a lower limit, $a_N$, of human capital for which rural workers would migrate to the US sector. It implies we would not observe extreme types of rural migrant workers in the US sector. Those rural workers with human capital close to $a_M$ who work in the RM sector, but who are not skilled enough to find a job in the UM sector, they can take advantage of affordable migration costs to earn higher wage in the US.

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\(^{12}\) The combination of a decreasing $C$ function plus a non-decreasing $w_r$ function may bring about another result: overall effect is always decreasing if $C$ dominates. The U-shaped curve also can be very asymmetric if $C$ is much flatter than $w_r$. Provided $w_{us}$ is greater than the minimum point of $w_r + C$, these two cases end up with only one intersection. In the first case, all highly skilled rural workers have an incentive to move to US; in the second case, all less smarter rural workers will move to US. These two are not consistent with the data.
sector. On the other hand, for those rural workers with human capital close to $a_N$ who are paid much less, the wage in the US sector will be attractive in spite of high migrating costs. Figure 2c also indicates that a higher migrating cost discourages rural workers from migrating to the US sector, and so we observe more homogeneity among migrant workers in the US sector.

Another application of figure 2c is to analyze different migration behavior from different rural areas and under different transportation technologies. China’s development is geographically uneven. The eastern coastal region is most developed, while the central and western regions are less-developed. Thus, the migrating cost for rural workers migrated from the western region is higher than someone migrated within the eastern region, assuming all other factors are the same. Therefore, given the same wage earned in urban areas, we would observe less migration from those rural areas located far away from big cities. The model can also be applied to the case of the replacement of general train by high-speed trains as a mean of transportation for rural migrants. General trains are the most popular means of transportation among rural migrants, especially during the Spring Festival Travel Season. However, as the development of China’s high-speed rail network, the low price general trains are being replaced by high-speed trains which seat is priced up to five time of the price of a general train ticket. The increase in cost of migration may deter rural residents to migrate.

**Proposition 3:** Two different equilibrium scenarios may appear in rural region after rural workers migrate to urban region. Rural workers with human capital in excess of $a_N$ migrate to the US sector. The workers with human capital level lower than $a_N$ could enter the RM sector or stay in the RA sector. These two scenarios are depicted in Figure 3.

### Figure 3 Career distribution in rural region

Fewer rural workers migrate to the US sector when migration costs are high (Figure 3a). From figure 2c, $a_N$ in Figure 3a is greater than $a_N$ in Figure 3b which has lower migrating costs. It implies a higher wage if the one on the boundary works in the RM sector. This provides room for rural workers with human capital slightly less than $a_N$ to earn higher wages in the RM sector than staying in the RA sector after some rural workers migrate to the US sector. The rural workers with human capital higher than $a_L$ can enter the RM sector after those with human capital between $(a_N, a_M)$ migrate to the US sector. The departure of some RM workers increases the physical capital per capita for the remaining RM workers, which encourages more farmers to enter the RM sector. Therefore we can observe two groups of human capital within which rural workers are in the RM sector: $(a_L, a_N)$ and $(a_M, a_X)$. The values of $a_N$, $a_M$ and $a_X$ identify the migrating populations and their occupational choices. In rural areas, people with human capital

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13 For example, from Hefei in Anhui Province to Shanghai, the high-speed train seat costs 205 yuan, while the general train seat only costs 38.5 yuan. However, the general trains are thought to be unprofitable and are being replaced in the process of railway network modernization.
between $a_N$ and $a_M$ migrate to the US sector, while those with human capital greater than $a_X$ go to the UM sector. Because people only migrate when they can obtain higher utility, the rural migrant workers and those former farmers who migrate to the RM sector are better off. Because the supply of labor in the US sector increases, it reduces wages in this sector, making the pre-existing urban poor worse off.

More rural workers can afford to migrate to the US sector when migration costs are low (Figure 3b). In this case, the marginal worker staying in rural region has lower human capital than when migration costs are high. Because of the low human capital endowments, of those who remain in rural areas, after those with human capital at $(a_N, a_M)$ migrate to the urban region, investment cannot support wages in the RM sector higher than those obtained by farming. In rural region, people with skills lower than $a_N$ work in the RA sector. People with human capital between $a_N$ and $a_M$ migrate to the US sector. Those with human capital between $(a_M, a_X)$ stay in the RM sector and those with human capital greater than $a_X$ will go to the UM sector. Therefore, all rural workers with human capital level higher than $a_N$ are better off. But because the supply of labor in the US sector increases more than that in the first case, it reduces incomes in this sector.

3 Minimum wage

Workers' moving decisions and the market outcomes with free labor mobility may be different with government intervention. To avoid a huge migration flow flushing into cities when the labor mobility constraint is removed, government can use minimum wage policies to smooth the transition, and to maintain subsistent living standards for low-income workers. Since it is effective to enforce minimum wage on formal sectors, we assume that minimum wage is imposed on the UM sector at $w$. It has significant effects on the labor market. To begin, we consider the UM workers.

Proposition 4: After labor becomes mobile, the minimum wage induces fewer urban workers to enter UM. The effects on migration to the UM sector depend on the value of the minimum wage. When $w$ is low, it induces more migrant workers to migrate to the UM sector, compared to the condition without a minimum wage. When $w$ is high, migrant workers are limited from moving to the UM sector and less migrant workers migrate to the UM sector.

Proof. We begin by considering the effects of $w$ on urban workers. Without any migrant workers, the UM employment is $N_{UM} = L_u \int_{a_u}^{1} p^u \, da$. When labor is mobile, total employment in the UM sector includes urban workers and migrant workers. That is, $N_{UM} = L_u \int_{a_u}^{1} p^u \, da + N_{MW}$ where $a_w$ is the least human capital that an urban worker can have and still stay in the UM sector, and $N_{MW} > 0$ is the number of migrant workers in the UM sector. When the minimum wage is enforced, it determines the least human capital with which the urban worker could stay in the UM sector. We have:

$$w = MPN_{UM}^m(a_w, \frac{K_u}{L_u \int_{a_w}^{1} p^u \, da + N_{MW}})$$

For any given urban human capital level, the RHS of equation (12) is less than $MPN_{UM}^m(a_w, \frac{K_u}{L_u \int_{a_w}^{1} p^u \, da})$, which is the wage of urban UM workers when labor is immobile,
since each worker will have less physical capital to work with. Figure 4 shows the effect of $w$ on urban workers.

![Graph showing the effect of $w$ on urban workers](image)

**Figure 4  The effects of $w$ on urban workers**

Because $w$ must be greater than $w_{us}$, $a_w$ is greater than $a_Z$. Figure 4 shows that when $w$ is enforced, the probability of fewer urban workers staying in the UM sector after labor becomes mobile is higher than in the case without $w$. If $w_{us}$ drops quickly after labor becomes mobile, we may observe more urban workers in the UM sector after the labor mobility constraints are removed.

With regard to the rural workers, there are two scenarios. If the MPN of marginal migrants when they work in the UM sector is greater than $w$, their decision is based on:

$$MPN_{aX}^{UM} - MPN_{aX}^{RM} = C(a_X) \quad (13)$$

where $MPN_{aX}^{UM}$ is the wage if the worker migrates to the UM sector and $MPN_{aX}^{RM}$ is the wage if the same worker stays in the RM sector. If we keep the same $a_X$ as before, since we expect fewer urban workers in the UM sector than in the case without $w$, only $MPN_{aX}^{UM}$ is affected, and will be higher than in the case without minimum wage. Therefore, the LHS of equation (13) must be reduced if it is to hold, which implies that more rural workers are moving to the UM sector.

Nevertheless, if $MPN_{aX}^{UM} < w$, then rural workers whose MPN when working in the UM sector is lower than $w$ are not accepted by any UM firms, because of the enforcement of the minimum wage. In this case the MPN of the last worker moving to the UM sector must be at least equal to $w$. That is:

$$MPN_{aX}^{UM} = w \quad (14)$$

The higher the minimum wage, the less qualified rural workers need be to migrate to the UM sector. Because $w$ also equals the MPN of the last urban workers who can stay in the UM sector, the lowest human capital levels are the same for both urban and rural workers.

The effects of $w$ on the decision to migrate to the US sector are not certain without making further assumptions about the properties of the functions. Generally speaking, it is
ambiguous because: on the one hand, \( w \) drives more urban workers to the US sector; and because \( w_{us} \) is negatively related to the US labor supply, we expect a lower value of \( w_{us} \) with a higher value of \( w \). On the other hand, since \( w \) reduces the income in the US sector, it provides less incentive for rural workers to migrate, which in turn has positive effects on the value of \( w_{us} \). It is reasonable to expect that high \( w \) induces a smaller migration flow to the US sector, since it lowers \( w_{us} \). The effects of minimum wages will be examined using simulations.

Because the minimum wage policy limits workers from entering UM, it protects UM workers but hurts US workers, since the US wage is lower with a higher \( w \). The lower \( w \) pushes some previous migrant workers in the US sector back to rural region, so that employment in the RA sector increases. This obviously hurts the RA workers. The effects on the welfare of other workers are ambiguous. In the next section, by using data from China, we simulate a calibrated model to provide various results for different values of \( w \).

4 Numerical analysis

In this section, we first make assumptions on specific functional forms that are consistent with all the previous assumptions about probability distribution functions of human capital, production functions, wage functions, etc. We use the 2006 data from China to calibrate our model, then use the calibrated model to simulate the effects of the minimum wage policy on the aggregate level and distribution of China's output. This is an extension of another calibration which is done by using data from 1986.\(^{14}\) The cut-offs of labor allocations \((a_N, a_M, a_X, a_Z)\) are the endogenous variables in our model. The values of free parameters are either based on real data \((L_u, L_r, K_u, K_r, \alpha_u, \alpha_r, \beta_u, \beta_r, A)\), standardized \((c_r, z_{rm}, z_a)\), or derived from theories which are consistent with the data \((c_u, z_{um}, a, \gamma)\). The outcomes are consistent with all theoretical assumptions.

4.1 Calibration

we assume human capital in both urban and rural region follows a triangular distribution on the domain \( a \in (0,1) \). The rural distribution peaks at \( c_r \) and the urban distribution peaks at \( c_u \).\(^{15}\) \( c_r \) is assumed to be 0.3 and \( c_u \) is 0.6867 which is calibrated when using 1986 data.\(^{16}\) The distribution of urban human capital thus has first-order stochastic dominance over which of rural human capital.

The manufacturing sector uses a Cobb-Douglas production function:

\[
y_{lm} = z_{lm} \cdot a_l \cdot N^{a_l} \cdot k_l^{b_l}
\]

RM is more labor intensive and has less value-added than UM.\(^ {17}\) Moreover Jin and Du (1997) suggests that \( \alpha_r \) is roughly equal to \( \beta_r \).\(^ {18}\) Given a CRTS production function, they are both assumed to be 0.5. Sharma (2007) estimates a Cobb-Douglas production function along with a time trend to capture the effect of technological progress after the reforms in 1978 using a cointegration and Error-Correction modeling framework for the 1952-1998 period. He found that the output elasticity for labor was about 0.37 under the assumption of constant returns to scale.

\(^{14}\) Please refer to Fu and Wang (2014) in which the calibration is also done using 1986 data.

\(^{15}\) The pdf of a triangle distribution is triangle shaped. It is \(2(x-A)/(B-A)(C-A))\) if \( A \leq x \leq C \), and it is \(2(B-x)/(B-A)(B-C))\) if \( C \leq x \leq B \), where \( A \) is the lower limit, \( B \) is the upper limit and \( C \) is the mode.

\(^{16}\) Please refer to Fu and Wang (2014) for the details.

\(^{17}\) Zen (2002) suggested that China's rural industry is more labor intensive, has a lower added-value and large bulk.

\(^{18}\) Please refer to Table 3.3 in Jin and Du (1997).
for all of China. Since rural industry accounted for roughly 1/5 of total industry, \( \alpha_u = 1/3 \) and \( \beta_u = 2/3 \).\(^{19}\) \( z_{rm} \) and \( z_{um} \) are free parameters in our model. Each worker's physical labor, \( N \), is normalized to 1 in both sectors. The total investment in urban and rural region was 2692.03 and 479.47 billion Yuan, respectively, in 1986 prices, which are used to approximate capital stock.\(^{20}\)

The relative price function is derived in Appendix A:

\[
P = \frac{y_{um} + y_{rm}}{A \cdot y_a}
\]  \( (16) \)

The total outputs of the first and second industries were 2473.7 and 10316.2 billion. Considering the openness of China’s economy in 2006, the ratio between the value of industrial goods and agricultural goods was about 1:3.6 in China; we assume \( A = 3.6 \).\(^{21}\)

The wage in the US sector is assumed to be \( \ln w_{us} = \gamma \ln y_{um} - \eta \ln N_{us} \). Using data from 1986 to 2008, we ran a regression of \( \ln \Delta y_{um} \) on \( \ln(\Delta N_{us}) \) and \( \ln(\Delta w_{us}) \) and have \( \eta = 1.23\gamma \).\(^{22}\) Accordingly, the wage function is assumed to be:

\[
w_{us} = \frac{(y_{um})^\gamma}{(N_{us})^{1.23\gamma}}
\]  \( (17) \)

The production function of RA is:

\[
y_a = z_a \cdot N_a^\alpha
\]  \( (18) \)

where \( \alpha \) is 0.6091.\(^{23}\) From 1986 to 2006, agricultural output increased by 120%, while agricultural employment changed from 312.53 million to 325.61 million. By keeping a constant and normalizing \( z_a \) in 1986, \( z_a \) is approximated to be 2.0678 for 2006.

Because workers are free to migrate between labor markets, all variables are pooled into one equation system. The migrating cost function is assumed to be:

\[
C(a) = c_F + \frac{1}{c_F a^2}
\]  \( (19) \)

where \( c_F \) is the fixed migrating cost.\(^{24}\)

In 2006, the urban labor force was 283.10 million and the rural labor force was 480.90 million. Of the 131.81 million rural migrant workers, 56.7% went to the industrial sector and 40.5% went to the service sector.

Based on the information above, the parameters in our current calibration are \( L_u = 283, L_r = 481, K_u = 2692, K_r = 479, A = 3.6, z_u = 2.0678, c_r = 0.3, c_u = 0.6867, \alpha_r = 1/2, \beta_r = 1/2, \alpha_u = 2/3, \beta_u = 1/3 \) and \( \alpha = 0.6091 \). We have \( z_{rm}, z_{um}, c_F \) and \( c_y \) as the free parameters.

The facts which we have tried to replicate are as follows:

---

\(^{19}\) The urban capital share is \( 0.63-(0.5-1/5)=0.53 \) and the urban labor share is \( 0.37-(0.5-1/5)=0.27 \). The ratio is roughly 2.

\(^{20}\) Because there is no data on China’s capital stock across periods, I use investment flow to approximate capital stock. We need very strong economic assumptions to do this approximation, such as assuming the depreciation rate, \( \delta \), is very high close to 1 as \( K = l/\delta \) at steady state.

\(^{21}\) This ratio is trade-adjusted. In 2006 China’s net exports totalled 1421.77 billion Yuan and most of it (97.5%) was produced by the industrial sector. (China Statistical Yearbook, 2007). Those numbers should be subtracted from total outputs to evaluate domestic preferences.

\(^{22}\) The coefficients of \( \ln(\Delta N_{us}) \) and \( \ln(\Delta w_{us}) \) are 1.23 and 0.71 with P-values 1.49E-08 and 8.90E-06. Adjusted \( R^2 \) is 0.9494.

\(^{23}\) The value of \( \alpha \) is calibrated using the 1986 data. Please refer to Fu and Wang (2014).

\(^{24}\) The moving cost function has two parts. The second term is used to approximate non-money costs, though "it would be difficult to quantify these costs" (Sjaastad (1962)).
1. In 2006, China’s rural labor force was 480.90 million, and employment in the rural industrial and private sectors was 194.59 million. We approximate the number of farmers by taking the difference between these two numbers, which is about 59.53% of the rural labor force.

2. China’s employment in the third industry is 32.20% of the total labor force.

3. After cancelling the manual migration costs imposed by the government, the transportation cost becomes the major explicit migrating cost. In China, long distance travel is mostly by rail. In 2006, the average rail fare was 57.93 RMB, and, generally, rural workers have to make at least one transfer to reach the big cities. Therefore, the round-trip fare would be 231.71 RMB, which is 6.45% of a farmer’s income in 2006.

4. Because industrial goods are normalized in our model, the outputs are comparable. The industrial output in 2006 was 9.33 times that of 1986.

After calibrating, the values of the free parameters are derived as: \( z_{rm} = 0.2181 \), \( z_{um} = 0.4416 \), \( c_F = 0.0195 \), and \( c_V = 30.219 \).

4.2 The second best outcome

The second best outcome occurs when utility is maximized aggregately with only one constraint: predetermined capital profile. Because the outputs of different sectors are involved in our model and they are not comparable, we must resort to the utility function to find the optimal outcome with which the total utility is maximized. The utility function is assumed to be a Cobb-Douglas, as shown in Appendix A. Calibrated using the 2006 data, it is

\[
U(x_A, x_M) = x_A^{3.6} x_M^2
\]

where \( x_A \) is the consumption of agricultural goods and \( x_M \) is the consumption of industrial goods. We assume consumers have homogeneous preferences, thus every consumer spend the same proportions of her income on both goods. In the second best case, the marginal product of labor from UM and from RM must be equalized for the same workers. If \( a_E \) is the optimal solution to the second best, the workers in both regions with human capital higher than \( a_E \) work in either RM or UM sector, and those with lower human capital work in agricultural sector, based on the assumption that US doesn’t produce real outputs. Therefore the optimization problem is to maximize equation 20 subject to

\[
a_r \cdot z_{rm} \cdot k_r^{\beta_r} = a_u \cdot z_{um} \cdot k_u^{\beta_u}
\]

which comes from \( MPN_{rm} = MPN_{um} \) for the same worker. Physical labor is normalized to 1. Since \( k_i = K_i / N_i \) where \( i = rm \) or \( um \), and \( N_i \) is the labor employed in each sector, equation 2.21 determines the migration flow: high-skilled rural workers migrate to the UM sector while low-skilled urban workers migrate to the agriculture sector. Because \( \beta_r \) and \( \beta_u \) are different, the problem is to maximize utility subject to a non-linear constraint. Given \( a_E \), the optimal allocation of labor can be found by equalizing \( MPN \)s; then \( k_r \) and \( k_u \) can be expressed as functions of \( a_E \), as are the outputs, \( y_{um} \), \( y_{rm} \) and \( y_a \), since they can be solved as functions of \( k_r \), \( k_u \) and \( a_E \), and since \( k_r \) and \( k_u \) are functions of \( a_E \), \( y_{um} \), \( y_{rm} \) and \( y_a \) are functions of \( a_E \). Therefore the utility function is also a function of \( a_E \) and we are able to find the optimal solution to maximize it.

Instead of solving this complicated non-linear optimization problem, we resort to simulations to find the optimal solution to it. The second best occurs when the boundary of human capital between the modern manufacturing sectors and the agricultural sector is 0.6112: those with human capital higher than 0.6112 enter either RM or UM, while those with lower human capital enter the agricultural sector. The total employment in the manufacturing sector is 232.92. But the distribution is very uneven: RM employs only 10.27, while UM employs 222.65, ensuring that a worker makes the same MPN in both sectors. The migration flow from RM to the UM sector is 93.56.
4.3 The market equilibrium outcome

4.3.1 Equations system

Due to the friction caused by the existence of migrating costs as well as the predetermined capital investment profile, the optimal market outcome may not be the best. For the same reason, even though minimum wage is always binding for urban workers, it may or may not be binding for the migrant workers, since they require higher incomes (and thus have higher MPN) to compensate their migrating costs.

The optimal market equilibrium outcome can be solved by maximizing agents’ utilities (equation 20) under certain constraints. To calculate the values of outputs, we need to find the critical values of human capital had by the marginal workers. The systems of equations which determine the outcomes are different depending on whether the minimum wage is binding for migrant workers. If it is not binding for migrant workers, i.e. \( w < MPN_{aX}^{UM} \), the system contains equations 22, 23, 24 and 25.

\[
\begin{align*}
    w_{uS} &= p \cdot w_a + C(a_N) \quad (22) \\
    w_{uS} &= MPN_{aM}^{RM} + C(a_M) \quad (23) \\
    w &= MPN_{aZ}^{UM} \quad (24) \\
    MPN_{aX}^{UM} &= MPN_{aX}^{RM} + C(a_X) \quad (25)
\end{align*}
\]

Equation 22 implies that the rural workers with human capital \( a_N \) are indifferent between working in the RA sector and the US sector. Equation 23 implies that the rural workers with human capital \( a_M \) are indifferent between working in the RM sector and US sector. Equation 24 implies that the urban workers with human capital \( a_Z \) are indifferent between working in the UM sector and US sector. Equation 25 implies that the rural workers with human capital \( a_X \) are indifferent between working in the UM sector and the RM sector, while migrant workers in the UM sector receive higher wages than the minimum wage. Minimum wage is binding for urban UM workers only, and all migrants workers in the UM sector earn higher wages than it.

If minimum wage is binding for migrant workers, i.e. \( w = MPN_{aX}^{UM} \), the system is almost the same as before, only with Equation 25 replaced by Equation 26. Thus it contains equations 22, 23 24 and 26.

\[
    w = MPN_{aX}^{UM} \quad (26)
\]

4.3.2 Simulations

Given the function forms and the calibrated values of parameters, we are able to solve for the optimal value of the minimum wage and use simulation to visualize its effects on the levels of utilities and outputs, provided it would yield a better outcome than the market-clearing wage \( MPN_{aZ}^{UM} \). It turns out that the optimal minimum wage is 0.4814, when minimum wage is just about to be binding for migrant workers. The optimal utility level is 740.58, compared with the market-clearing UM wage of 0.4725 which yields the utility level 728.71.\(^{25}\) The effects of minimum wage on the values of outputs and levels of utility are visualized in Figure 5.

\(^{25}\) I have done a positive monotonic transformation on the initial form of the utility function so that the values of the utilities are close to the values of output, and so they can be shown in the same figure, as in Figure 5.
Furthermore, we compare the market equilibrium outcomes for three different levels of minimum wage: a low level of 0.4750, the optimal level of 0.4814 and a high level of 0.4900, to show the detailed effects on outputs, inequalities and welfare changes from different values of minimum wages. When $w$ is low, the minimum wage is not binding for rural migrant workers, though it is just binding when $w$ is optimal, and it is strictly binding when $w$ is high. The equilibrium outcomes are shown in Table 1.

<table>
<thead>
<tr>
<th>$w$</th>
<th>$a_Z$</th>
<th>$a_N$</th>
<th>$a_M$</th>
<th>$a_X$</th>
<th>$y_a$</th>
<th>$y_m$</th>
<th>$y_{us}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0.6214</td>
<td>0.4678</td>
<td>0.6039</td>
<td>0.6342</td>
<td>64.86</td>
<td>510.74</td>
<td>116.25</td>
</tr>
<tr>
<td>Low</td>
<td>0.6237</td>
<td>0.4681</td>
<td>0.6028</td>
<td>0.6329</td>
<td>64.90</td>
<td>511.33</td>
<td>116.35</td>
</tr>
<tr>
<td>Optimal</td>
<td>0.6295</td>
<td>0.4690</td>
<td>0.5998</td>
<td>0.6295</td>
<td>64.98</td>
<td>512.78</td>
<td>116.61</td>
</tr>
<tr>
<td>High</td>
<td>0.6332</td>
<td>0.4772</td>
<td>0.5971</td>
<td>0.6332</td>
<td>65.80</td>
<td>474.32</td>
<td>105.94</td>
</tr>
</tbody>
</table>

$w$ is the minimum wage. $a_Z$, $a_N$, $a_M$, $a_X$ are the employment of rural migrant workers, urban migrant workers, self-employed workers, and employers, respectively. $y_a$, $y_m$ and $y_{us}$ are the utility of rural migrant workers, urban migrant workers and the US sector, respectively. $w_a$, $p$, $MPN_{RA}$, $MPN_{RM}$, $MPN_{RM_{a_M}}$, $MPN_{RM_{a_X}}$ are the wage of rural migrant workers, price, market potential of rural migrant workers, market potential of urban migrant workers, market potential of self-employed workers, and market potential of employers, respectively. $N_{RA}$, $N_{RM}$, $N_{UM}$, $M_{UM}$, $M_{US}$ are the number of rural migrant workers, urban migrant workers, self-employed workers, employers, and the US sector, respectively. $w_{IM}$, $w_{IZ}$ are the wage of rural migrant workers, urban migrant workers, respectively. $N_{RA}$, $N_{RM}$, $N_{UM}$, $M_{UM}$, $M_{US}$ are the number of rural migrant workers, urban migrant workers, self-employed workers, employers, and the US sector, respectively. $w_{IM}$, $w_{IZ}$ are the wage of rural migrant workers, urban migrant workers, respectively.

As $w$ increases, the size of the UM employment becomes smaller, and it decreases by 0.23%, 0.85% and 2.59%, when compared to the case without $w$. In the US sector, wage
decreases by 0.03%, 70.12% and 7.18%. The income of farmers changes by 0.03%, 0.09% and -9.29%. Regarding migration flows to the UM sector, \( M_{UM} \), when \( w \) is low, the migration flow is 92.60. It increases to 94.31 when \( w \) is the optimal, and decreases to 92.46 when \( w \) is high. When \( w \) is low, the migration flow to the US sector, \( M_{US} \), is 86.01. When \( w \) is optimal or high, \( M_{US} \) is 83.71 and 76.32, respectively.

Imposing a minimum wage has significant effects on the values of outputs. Table 2 summarizes the changes with different minimum wages.

<table>
<thead>
<tr>
<th>Output value</th>
<th>( y_a )</th>
<th>( y_a )</th>
<th>( y_a )</th>
<th>Total value</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ( w )</td>
<td>141.88</td>
<td>510.74</td>
<td>116.25</td>
<td>768.87</td>
<td></td>
</tr>
<tr>
<td>Low ( w )</td>
<td>142.03</td>
<td>511.44</td>
<td>116.35</td>
<td>769.72</td>
<td>0.11%</td>
</tr>
<tr>
<td>Optimal ( w )</td>
<td>142.44</td>
<td>512.78</td>
<td>116.61</td>
<td>771.82</td>
<td>0.38%</td>
</tr>
<tr>
<td>High ( w )</td>
<td>131.75</td>
<td>474.32</td>
<td>105.94</td>
<td>712.02</td>
<td>-7.39%</td>
</tr>
</tbody>
</table>

An interesting result is seen when the minimum wage is a little higher than the market-clearing wage, as it helps economic growth. Because of the existence of migrating costs, the marginal migrant workers in the UM sector require higher income when they work in the UM sector than when they work in the RM sector, given there is no minimum wage. Since only the relatively low-skilled workers in the RM sector would consider moving to the US sector to earn \( w_{US} \), which is the same as the lowest wage for urban UM workers, the marginal migrant workers (who are relatively high-skilled) in the UM sector must earn a higher wage than the lowest wage earned by urban UM workers. This difference provides room for the minimum wage to be set between these two wages. At the time that \( w \) greater than the lowest wage earned by urban UM workers is enforced on urban formal sector, if it is lower than the wage earned by marginal the migrant workers when there is no minimum wage, it is only binding for urban workers but not for migrant workers. Thus it drives some urban, low-ability workers at the margin out of the UM sector, and they are replaced by comparatively high-ability, rural migrant workers. Thus the output of the UM sector increases. More output from the UM sector, in turn, benefits the workers in the US and RA sectors. When the minimum wage is high enough to restrain the more efficient rural workers from moving, however, it hurts economic growth. We would expect that the higher the minimum wage, the lower the value of the total output.

With regards to the changes of inequality, we compare the income of workers with human capital equal to 0.8 with that of the majority in rural region. Because the gap between capital income and labor income is the main source of inequality in urban region, we mean to show the changes of the ratio between capital income and that of US workers. They illustrate the intra-area inequality change. We also calculate the Gini coefficients, derived from labor income only, since we lack data about the number of capital owners and the distribution of capital incomes. The inequality changes are shown in Table 3.\(^{26}\)

---

\(^{26}\) Because I lack data about the number of capital owners, I assume the ratio between the incomes of capital owners and US workers is \( q \) when no minimum wage is present, given that the income is equally distributed among capital owners.
Table 3  The effects of \( w \) on inequalities

<table>
<thead>
<tr>
<th>Income</th>
<th>Rural inequality change</th>
<th>Urban inequality change</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \alpha_r=0.8 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ( w )</td>
<td>0.6083</td>
<td>0.3018</td>
<td>2.0158</td>
</tr>
<tr>
<td>Low ( w )</td>
<td>0.6093</td>
<td>0.3019</td>
<td>2.0183</td>
</tr>
<tr>
<td>Optimal ( w )</td>
<td>0.6118</td>
<td>0.3921</td>
<td>2.0254</td>
</tr>
<tr>
<td>High ( w )</td>
<td>0.6191</td>
<td>0.2738</td>
<td>2.2614</td>
</tr>
</tbody>
</table>

In rural region the workers with human capital of 0.8 work in the UM sector. When \( w \) is low, their incomes are 0.6093, which is 2.02 times that of a farmer's income. When \( w \) is set at optimal, in rural region those with human capital of 0.8 earn 0.6118, which is 2.03 times that of a farmer's income. When \( w \) is high, in rural region those with human capital of 0.8 earn 0.6191, which is 2.26 times that of a farmer's income. Table 3 indicates that inequality becomes worse in rural region when \( w \) increases.

In urban region the effect of \( w \) is very small when \( w \) is low or optimal, and it decreases by 2.35% when \( w \) is high. The income of capital owners changes by 0.36%, 0.43% and -7.51% respectively. The minimum wage increases the income ratio between capital owners and US workers when it is not binding for migrant workers, while it decreases this ratio when it is binding for migrant workers. The Gini coefficient, which is based on labor income only, keeps increasing from 0.1470 to 0.1737, suggesting that labor-income inequality is worsened with higher minimum wage for the whole country.

4.3.3 Welfare change

Because a minimum wage can restrict labor from entering the industrial sector, it benefits the workers who stay in the UM sector. The effects on other workers depend on the value of the minimum wage. If the minimum wage is low and very close to the market equilibrium price, it may slightly benefit most workers, though the effects would be limited. If the minimum wage is slightly above the market equilibrium price, no rural workers will benefit from it. Table 4 and Table 5 compare the welfare changes for both rural and urban workers when the minimum wages are set at optimal (0.4814) and high (0.49), respectively. Figure 2 and Figure 3 indicate the changes of career allocations when the minimum wages are optimal (0.4814) and high (0.49), respectively. These tables indicate that a low minimum wage slightly benefits most workers. However, a high minimum wage benefits the migrant workers in the UM sector at a high cost to all other workers.

Table 4  Welfare change after \( w = 0.4814 \) is enforced

<table>
<thead>
<tr>
<th>Rural workers human capital (# of workers, % in local labor force)</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>[0.4678, 0.4690) (286.34, 59.53%)</td>
<td>0.3018</td>
<td>0.3018</td>
</tr>
<tr>
<td>(0.4690, 0.5998) (83.71, 22.8%)</td>
<td>0.3026-0.3026</td>
<td>0.3021-0.3021</td>
</tr>
<tr>
<td>[0.5998, 0.6039) (2.28, 0.47%)</td>
<td>0.3610-0.3623</td>
<td>0.3606-0.3610</td>
</tr>
<tr>
<td>[0.6039, 0.6295) (13.48, 2.80%)</td>
<td>0.3623-0.3777</td>
<td>0.3625-0.3784</td>
</tr>
</tbody>
</table>
### Rural workers human capital (number of workers, % in local labor force)

<table>
<thead>
<tr>
<th>% Δ</th>
<th>Before</th>
<th>After</th>
<th>% Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09</td>
<td>0.3606</td>
<td>0.3631</td>
<td>0.21</td>
</tr>
</tbody>
</table>

### Urban workers human capital (number of workers, % in local labor force)

<table>
<thead>
<tr>
<th>% Δ</th>
<th>Before</th>
<th>After</th>
<th>% Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09</td>
<td>0.3606</td>
<td>0.3631</td>
<td>0.21</td>
</tr>
</tbody>
</table>

**Table 5** Welfare change after \( w = 0.4900 \) is enforced

**Rural Area**

<table>
<thead>
<tr>
<th>Without ( w )</th>
<th>RA</th>
<th>US</th>
<th>RM</th>
<th>UM</th>
<th>Without ( w )</th>
<th>RA</th>
<th>US</th>
<th>RM</th>
<th>UM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.4678</td>
<td>0.6039</td>
<td>0.6342</td>
<td>1</td>
<td>0</td>
<td>0.6214</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( w = 0.4814 )</td>
<td>RA</td>
<td>US</td>
<td>RM</td>
<td>UM</td>
<td>US</td>
<td>UM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.4689</td>
<td>0.5998</td>
<td>0.6295</td>
<td>1</td>
<td>0</td>
<td>0.6295</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Urban Area**

**Figure 6** Career distributions after after \( w = 0.4814 \) is enforced
China adopted a minimum wage policy in the 1990s when its physical labor mobility constraints were virtually removed. Table 4 shows the effects of enforcing $w$. First, it protects the insiders in the UM sector by inducing fewer workers to join the UM sector; thus $k_u$ is greater, and every insider would earn a high wage. Nevertheless, the benefits enjoyed by the UM insiders come at a cost to the majority of other workers in the economy when the minimum wage is slightly higher than $w_{us}$, in particular, US and RA workers receive lower incomes. The effects on RM workers are uncertain: a low $w$ benefits them as more high-ability rural workers leave RM for UM, while the median and high values of $w$ may hurt them because many high-ability rural workers may have to stay in the RM sector. Second, enforcing $w$ would have significant effects on migration flows, depending on the value of $w$. When $w$ is low, the MPN of the marginal migrant worker to the UM sector is higher. Since fewer urban workers would stay in the UM sector, the low $w$ would attract more migrant workers to work in the UM sector. The migration flow to the UM sector would thus be greater than before. In contrast, when $w$ is high, the market equilibrium MPN of the marginal migrant worker to the UM sector is smaller, and the enforcement of a minimum wage would restrain rural workers from moving to the UM sector, causing the migration flow to the UM sector to drop. The effect on the migration flow to the US sector, $M_{us}$, depends on two factors: $w_{us}$ and the payoff from the rural sectors. When $w$ increases, fewer rural workers would be willing to migrate to the US sector.

An important consideration is the effect of $w$ on the development of the economy as a whole, as well as on adjustments to social inequality. When the minimum wage is not high enough to constrain the qualified rural workers from moving to the UM sector, the economic grows, since the low-skilled urban workers are replaced by relatively high-skilled migrant

<table>
<thead>
<tr>
<th>Rural Area</th>
<th>Urban Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without $w$</td>
<td>RA</td>
</tr>
<tr>
<td>$w = 0.4814$</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 7**: Career distributions after after $w = 0.4900$ is enforced
workers.; on the other hand, a insufficiently high minimum wage hurts economic growth since skilled workers are constrained from entering UM which would reduce aggregate outputs. In rural region, a minimum wage enhances inequality: the higher the minimum wage, the worse the inequality in rural region. In urban region, imposing a minimum wage has the opposite effect, inducing a quicker drop in the capital owners’ incomes relative to the incomes of US workers. Thus a high minimum wage enhances inequality in rural region, but improves it in urban region. The combination of imposing a minimum wage and controlling migrating costs may yield a better balance between economic development and reducing inequality.

Keeping the assumption of surplus labor in the agriculture sector, and focusing on manufacturing sectors only, when compared with the second best outcome in which the workers with human capital higher than 0.6112 work in the manufacturing sectors, we notice that the RM sector has some lower skilled workers while the UM sector has higher skilled workers at the market equilibrium. To achieve the second best outcome, the minimum requirements on human capital must be the same for the RM and UM sectors, implying that $a_M = a_Z$. Since rural workers with $a_M$ are indifferent between entering either the US or the RM sectors, and since urban workers with $a_Z$ are indifferent between entering the US or UM sectors, $a_M$ is smaller than $a_Z$ provided migrating costs exist. Thus, to make them equal, the migrating costs must be fully compensated for those migrant workers moving from RM to the US sector. Such compensation could be provided to encourage the RM workers at the margin to migrate to urban region. Furthermore, since minimum wage policy can be used to adjust the minimum human capital with which workers stay in the manufacturing sectors, it need not be binding for migrant workers in the UM sector. Otherwise, since $a_X = a_Z$, $a_M$ must be smaller than $a_Z$.

Although China has increased the level of its minimum wages several times recently, many export-oriented enterprises in eastern coastal areas (even in the central region of China) cannot recruit enough rural migrants to fill their orders. This fact does not imply that our model fails but model parameters or functional forms change, especially the migrating costs (in which the portion of non-money psychic cost has been increasing dramatically, due to extreme long working hours, wage arrears, etc.). In the meantime, rural workers have less incentive to migrate because of the improved working conditions in rural region. Those changes bring about transitions back and forth off equilibrium. Even though increasing wages and/or decreasing migrating costs may attract more migrant workers, the enforcement costs would also increase dramatically. Instead, allocating physical capital by considering the labor force allocation may be more effective in increasing the output of the manufacturing sectors. This would require a change in government strategy. When urban region have significant advantages over rural region, labor follows capital. Nowadays, since transportation, medical and education systems have been much improved in rural region, capital may start to follow labor.

6 Conclusion

In this paper, we present a theoretical model with heterogeneous agents, endogenous internal migration, and endogenous labor markets, and calibrate this model to analyze the effects of China's minimum wage policy on its economic development and inequality issues within the country's urban and rural region. Because China's government adopted an urban-biased investment strategy since it was founded, the investment decisions are exogenous in the model as the source of inequality between urban and rural region. Nevertheless, as heterogeneous workers...

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27 Please refer to a report, The Investigation on the Shortage of Migrant Workers, which was published by South Weekend (Nanfang Zhoumo) on March 3rd, 2011.
are looking for jobs in two regions (urban and rural region) and across four sectors (urban modern industry sector (UM), urban subsistence sector (US), rural modern industry sector (RM), and rural traditional agricultural sector (RA)), at equilibrium, high-ability rural workers go to the UM sector, while workers who stay in the RM sector may come from two discontinuous groups. All workers who are between the two groups have an incentive to migrate to the US sector. An enforced minimum wage may have different effects on the economy, depending on whether or not it is binding for migrant workers in the urban industrial sector. If not, the minimum wage policy replaces low-skilled urban UM workers with relatively high-skilled migrant workers, benefiting the whole economy. Otherwise it negatively affects the whole economy, while helping to slow down the inequality enhancement in cities. To achieve the second best outcome, full compensation of migrating costs should be given to the marginal migrant workers from the RM to the US sector, and the minimum wage should not be binding for migrant workers in the UM sector.

Although most stylized facts related to China's internal migration can be explained from our model, it has several weaknesses that point to possible extensions in future research, besides potential improvement in specific function forms. First, the economy in our model is assumed to fully follow market principles. In the real world, however, China is still transitioning from a planned economy to a market economy, though it has already changed from a closed economy to a large open economy during the process of marketization. Our model does not capture the price distortion occurring at the beginning of China's economic reform or some features of an open economy. Second, our model is a static model and no dynamics are included in the agent's utility function, while in reality people think not only about their current benefits but also about their future welfare. This static model also fails to explain the urban-rural inequality change. Third, though we mention that human capital can be influenced by education and job training, we do not assume options for agents to accumulate human capital. Because urban region have better education resources, another incentive is present for the rural workers to migrate. Such issues are explicitly clear in Lucas (2004). Fourth, since no unemployment is present, no uncertainty exists in our model, which is not consistent with the actual economy. Many economists have presented reasons for unemployment. For example, Harris and Todaro (1970) proposed a random job selection process over an excess labor supply; Cooper (1985) studied involuntary unemployment from asymmetric information; and Andolfatto (2008) analyzed unemployment by using a search model. These authors all provide good hints on how to incorporate unemployment into the present model.

References

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28 China began its economic reform in 1979 and declared its market economy in 1992. As of February 2008, China's market economy status has not yet been recognized by the US or the EU, though it has been recognized by 77 other countries.

29 The price scissors between industrial goods and agricultural goods existed in China until 1992 when the country declared itself as a market economy. See Lin and Yu(2009).


Appendices

Appendix A: relative price forming

Assume the homogeneous utility function over agricultural and industrial goods is:

\[ U(x_A, x_M) = x_A^a x_M^b \]  \hspace{1cm} \text{(A1)}

With different income levels \( m_i \) and a normalized price of industrial goods, the optimal consumption of each person is:

\[ x_A^* = \frac{q}{a+b} m_i \]  \hspace{1cm} \text{(A2)}

\[ x_M^* = \frac{b}{a+b} m_i \]  \hspace{1cm} \text{(A3)}

We have:

\[ \frac{x_A^*}{x_M^*} = \frac{a}{b} \]  \hspace{1cm} \text{(A4)}

To clear the market, \( x_A^*/x_M^* \) must equal \( y_a/y_M \) which gives us:

\[ P = \frac{a}{b} \left( \frac{y_a}{y_M} \right)^{-1} \]  \hspace{1cm} \text{(A5)}

Generalizing it we assume the relative price forming function as equation 4.

Appendix B: mathematical equilibrium in figure 3a

Mathematically, employment levels in the urban sectors, \( N_{us} \) and \( N_{um} \) are defined as:

\[ N_{us} = L_r \int_{a_M}^{a_N} p^r(a_r) da_r + L_u \int_0^{a_Z} p^u(a_u) da_u \]  \hspace{1cm} \text{(B1)}

\[ N_{um} = L_r \int_{a_M}^{1} p^r(a_r) da_r + L_u \int_0^{a_Z} p^u(a_u) da_u \]  \hspace{1cm} \text{(B2)}

Because some previous farmers would migrate to the RM sector, the employment levels in rural region now change. Now a farmer with human capital \( a_L \) is indifferent between working in the RA sector or RM, and the employment levels in the RA sector and RM are:

\[ N_{RA} = L_r \int_0^{a_L} p^r(a_r) da_r \]  \hspace{1cm} \text{(B3)}

\[ N_{RM} = L_r \int_{a_L}^{a_N} p^r(a_r) da_r + L_r \int_{a_M}^{a_X} p^r(a_r) da_r \]  \hspace{1cm} \text{(B4)}

The relative price, \( P \), is defined as:

\[ P = \rho \left( \frac{y_a}{y_{um} + y_{rm}} \right) \]  \hspace{1cm} \text{(B5)}

where \( y_a, y_{rm} \) and \( y_{um} \) are defined as:
At equilibrium, the rural worker with \( a_L \) must be indifferent between farming and working in the RM sector; that is:

\[
h''_N \left( a_L, \frac{K_r}{N_{RM}} \right) = P \cdot g'(N_{RA}) \tag{B9}\]

For the rural worker with \( a_N \) who is indifferent between working in the RM sector and US:

\[
h''_N \left( a_N, \frac{K_r}{N_{RM}} \right) = w_{us}(y_{um}, N_{US}) - C(a_N) \tag{B10}\]

For the rural worker with \( a_M \) who is indifferent between working in the RM sector and US:

\[
h''_N \left( a_M, \frac{K_r}{N_{RM}} \right) = w_{us}(y_{um}, N_{US}) - C(a_M) \tag{B11}\]

For the rural worker with \( a_X \) who is indifferent between working in the RM sector and UM:

\[
h''_N \left( a_X, \frac{K_r}{N_{RM}} \right) = f''_N \left( a_X, \frac{K_u}{N_{UM}} \right) - C(a_X) \tag{B12}\]

For the urban worker with \( a_Z \) who is indifferent between working in the US sector and UM:

\[
w_{us}(y_{um}, N_{US}) = f''_N \left( a_Z, \frac{K_u}{N_{UM}} \right) \tag{B13}\]

With the expression of \( P \) which is shown in equation B5, the equation system with equation B9, B10, B11, B12 and B13 determines the values of \( a_L, a_N, a_M, a_X, a_Z \). To make extra labor enter RM, at equilibrium the solutions must satisfy:

\[
h''_N \left( a_N, \frac{K_r}{N_{RM}} \right) \geq P \cdot g'(N_{RA}) \tag{B14}\]

**Appendix C: mathematical equilibrium in figure 3b**

\( N_{RM} \) is the employment in the RM sector:

\[
N_{RM} = L_r \int_{a_m}^{a_X} p^r(a_r) \, da_r \tag{C1}\]

The wage of farmers is:

\[
w = P \cdot \frac{y_a}{y_{rm} + y_{um}} \tag{C2}\]

where \( P \) is the relative price which is determined by:

\[
P = \rho \left( \frac{y_a}{y_{rm} + y_{um}} \right) \tag{C3}\]

where \( y_a, y_{rm}, \) and \( y_{um} \) are the equilibrium outputs of RA, RM and UM sectors, which are defined in equation C7, C8, and C9.

The employment levels of RA, US and UM are:

\[
N_{RA} = L_r \int_{a_n}^{a_N} p^r(a_r) \, da_r \tag{C4}\]

\[
N_{US} = L_r \int_{a_m}^{a_M} p^r(a_r) \, da_r + L_u \int_{a_z}^{a_U} p^u(a_u) \, da_u \tag{C5}\]

\[
N_{UM} = L_r \int_{a_X}^{1} p^r(a_r) \, da_r + L_u \int_{a_z}^{1} p^u(a_u) \, da_u \tag{C6}\]

The outputs of RA, RM and UM are:

\[
y_a = g(N_{RA}) \tag{C7}\]

\[
y_{rm} = L_r \int_{a_m}^{a_X} h\left( a_r, \frac{K_u}{N_{RM}} \right) p^r \, da_r \tag{C8}\]

\[
y_{um} = L_r \int_{a_X}^{1} f\left( a_r, \frac{K_u}{N_{UM}} \right) p^r \, da_r + L_u \int_{a_z}^{1} f\left( a_u, \frac{K_u}{N_{UM}} \right) p^u \, da_u \tag{C9}\]

The rural worker with \( a_N \) must be indifferent between working in agricultural and US; that is:
The rural worker with $a_M$ must be indifferent between working in the RM sector and US; that is:

$$h'_N\left(\frac{k_r}{N_{RM}}\right) = w_{us}(y_{um}, N_{US}) - C(a_M) \quad (C11)$$

The urban worker with $a_X$ must be indifferent between working in the RM sector and UM; that is:

$$h'_N\left(\frac{k_r}{N_{RM}}\right) = f'_N\left(\frac{k_r}{N_{UM}}\right) - C(a_X) \quad (C12)$$

Because our employment functions and output functions are all of $a_N, a_M, a_X$ and $a_Z$, the equilibrium values are determined by solving the equation system containing $C10, C11, C12,$ and $C13$. To make no extra labor enter RM, at equilibrium the solutions must satisfy:

$$h'_N\left(\frac{k_r}{N_{RM}}\right) \leq P \cdot g'(N_{RA}) \quad (C14)$$