A Numerical Simulation Analysis of (Hukou) Labour Mobility Restrictions in China *

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Abstract

We use numerical simulation methods to analyze the Hukou system of permanent registration in China which many believe has supported growing relative inequality over the last 20 years by restraining labour migration both between the countryside and urban areas and between regions and cities. Our aim is to inject economic modelling into the debate on sources of inequality in China which thus far has been largely statistical. We first use a model with homogeneous labour in which wage inequality across various geographical divides in China is supported solely by quantity based migration restrictions (urban – rural areas, rich – poor regions, eastern coastal – central and western (non-coastal) zones, eastern and central – western development zones, eastern – central – western zones, more disaggregated 6 regional classifications, and an all 31 provincial classification). We calibrate this model to base case data and when we remove migration restrictions all wage and most income inequality disappears. Results from this model structure point to a significant role for Hukou restrictions in supporting inequality in China. We then present a further model extension in which urban house price rises retard rural–urban migration. The impacts of removing Hukou restrictions on migration are smaller, but are still significant. Finally, we modify the model to capture labour productivity differences across regions, calibrating the modified model to estimates of both national and regional Gini coefficients. Removal of migration barriers is again inequality improving but less so.

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1 Introduction

The statistical literature on inequality in China (Bramall and Jones (1993), Chen (1996), Hare and West (1999), Jalan and Ravallion (1998), Kanbur and Zhang (1999), Lyons (1991), Rozelle (1994), and Tsui (1991, 1993, 1996, 1998a, 1998b)) is widely interpreted as pointing to growing national relative inequality in recent years. According to received wisdom based on some of this literature, the national Gini coefficient from China on income inequality has increased to over 0.4 from 0.3 over the last 15 years or so. This change coexists with more slowly growing inequality within the urban and rural segments of the economy (as measured by Gini coefficients), and also within coastal zones and inland segments of the economy. A sharp increase in the income/capita gap across these divides is usually taken to account for increased national relative inequality. Absolute poverty as measured by head count ratios and other measures consistently falls in Chinese data reflecting strong GDP growth in recent years.

A number of attempts have been made to account for this inequality change profile using statistical techniques as in the literature listed above. Econometric literature including Zhao (1999) and Shi, Sicular and Zhao (2004) focuses mainly on the determinants of migration decisions, and not on the size of the efficiency gains involved nor impacts on wage rates in a consistent micro based structure model. Our aim here is to use numerical simulation methods to provide fresh insights on these dimensions of the issue.

We focus on the system of Hukou in China, or registered permanent residence, which is location specific. Not having Hukou in urban areas means that migrants receive no education or health benefits and cannot purchase housing, since title to it cannot be registered by them. Effectively, Hukou operates as a barrier to urban/rural migration in China and supports large regional wage differentials which labour markets do not compete away. We ask how much inequality there would have been in China without the Hukou system.

Our starting point is the literature on the global consequences of immigration restrictions (see Hamilton and Whalley (1984)). In this literature, differences in both wage rates and GDP/capita across countries are assumed to be supported by immigration restrictions in a world with country specific factor inputs and downward sloping marginal product of labour schedules for otherwise potentially mobile labour. Parameters for an assumed underlying technology are calibrated so as to be consistent with observed data on wage differentials, labour shares of income, and GDP and population by country, and counterfactuals are performed to analyze the impacts of immigration barrier removal. Assumptions that there is homogeneous labour across countries or that there are efficiency differences across countries are used as alternatives in these exercises.

Here we make calculations for China as to what the impacts of removing internal (Hukou) barriers to regional labour mobility on inequality could be using data on both aggregate and regional GDP/capita using similar methods. In so doing we elaborate on the earlier methodology used to analyze global migration restrictions by using a simple basic model which we sequentially modify in further model elaborations. We first ignore inequality within regions and treat labour as homogeneous both across regions and across individuals. In this model wage rates across regions are equalized when

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migration restrictions are removed. With region specific fixed factors, regional differences in GDP / capita do not disappear with barrier removal although they fall sharply and national inequality is much reduced. Significant efficiency gains also accrue from barrier removal in this model. We also discuss the implications of relaxing the assumption of region specific immobile capital for results.

We then introduce region specific house price effects and capture their dampening impacts on migration. This is motivated by the desire to also capture the impacts of increases in urban house prices and housing rents in China on urban - rural mobility over the last 10 years. We develop a two good general equilibrium model with goods and housing, in which location specific housing stocks support differing urban and rural house prices. In equilibrium migration equalizes the real value of wage rates and we incorporate differences in house prices across regions through region specific true cost of living indices. Removing Hukou restrictions in this model again generates labour flows into urban areas which now drive up urban house prices which in turn dampens migration. Labour flows under Hukou removal are smaller, and significant redistribution occurs between urban dwellers whose house prices rise and rural dwellers whose house prices fall.

Finally, we extend the basic model by also assuming a distribution of labour productivities (or efficiency types) within each region and calibrate an extended model to both regional and national estimates of Gini coefficients before barrier removal, and also regional and national data on GDP / capita. Here, to simplify things, we assume that when mobility occurs across regions a representative segment or slice of the distribution of productivities moves and adds result to the distribution within the receiving region proportional to that distribution. We again remove migration barriers and calculate national inequality in the absence of Hukou restrictions. Significant efficiency impacts again occur but reductions in national inequality are smaller.

While findings from these exercises are data and parameter sensitive, they nonetheless jointly point to significant impacts from the Hukou system in supporting growing overall relative inequality in China, and significant efficiency gains from its removal. They also show how economic modelling as well as statistical techniques can be used to analyze inequality change from doing refer in not only for China but also for other countries.
2 Analysis of Hukou Restriction Removal Using A Basic Model

The objective of our paper is to assess how inequality in China might behave were it not for the Hukou system of permanent registration acting as a set of restrictions on labour mobility. We calibrate models of inter-regional labour mobility in China to base case data in the presence of Hukou restrictions and eliminate these restrictions. We then use the model generated counterfactual equilibria to assess how many people might migrate, and what the economy wide efficiency gains might be. In a later model extension we calibrate both no national and regional Gini coefficients and calculate how these change when individuals differ within regions.

We first use a simple model in which each region produces a single good \( Y \) according to a region specific production function in which labour enters as a homogeneous factor input which is mobile across all regions. We first assume region specific fixed factors (retns) which yield decreasing returns to scale and so in the fully mobile labour case even if wage rates are equalized across regions, GDP per capita across regions will not be.

In this simplest version labour is the only factor of production which is mobile across regions and capital is a fixed factor immobile across regions. We later relax this assumption and consider mobile capital as well as labour. In this simplest model form the regional production function is

\[
Y_s = f_s(L_s), \quad s = 1, \ldots, S
\]

where \( Y_s \) is production in region \( s \), \( L_s \) is labour used in region \( s \), \( f'_s > 0 \) and \( f''_s < 0 \). We assume that \( \sum L_s = L \) (full employment), and labour market clearing across regions determines the common wage \( W = W_s (s = 1, \cdots, S) \), where there are no barriers to labour mobility.Labour receives its marginal product in all regions in this case and

\[
W = f'_s(L_s), \quad s = 1, \ldots, S.
\]

If there are barriers to mobility of labour across regions, then the interregional labour allocation no longer corresponds to that supporting a market clearing wage. Suppose this allocation is given as \( L^0_s \) \( (s = 1, \cdots, S) \) such that \( \sum L^0_s = L \), then the marginal products of labour across regions will differ and wage rates \( W_s (s = 1, \cdots, S) \) will also differ, i.e. \( f'_s(L^0_s) \) differs across \( s \). Removing interregional barriers to labour mobility in this case implies an efficiency gain for the economy if marginal products of labour are the equalized across regions.

Figure 1 illustrates the case of a 2 region urban - rural economy. Here, initial migration restrictions support wage rate differences across regions while the common wage \( W = W_U = W_R \) applies when migration restrictions are removed. Income per capita across the two regions still differs with no migration restrictions as region specific rents differ. Income inequality is much reduced but not eliminated in this case as wage rates converge across regions. An efficiency gain accrues, as shown, to the whole economy.
If we assume a diminishing marginal product production function in each region of the form

$$Y_s = A_s L_s^{\alpha_s}, \quad s = 1, \ldots, S$$  \hspace{1cm} (3)

then with decreasing marginal productivity of labour the regional wage $W_s$ is given as

$$W_s = \frac{\partial Y_s}{\partial L_s} = \alpha_s A_s L_s^{\alpha_s - 1}, \quad s = 1, \ldots, S$$  \hspace{1cm} (4)

and regional rents, $R_s$, are \textsuperscript{1}

$$R_s = Y_s - W_s L_s, \quad s = 1, \ldots, S.$$  \hspace{1cm} (5)

Income in region $s$, $I_s$, is given by

$$I_s = Y_s, \quad s = 1, \ldots, S.$$  \hspace{1cm} (6)

and, assuming equal proportional shares in rents within the region, income per worker in each region, $J_s$, is given by the average product of labour $J_s = \frac{I_s}{L_s} = \frac{Y_s}{L_s}, \quad s = 1, \ldots, S$.

In equilibrium

$$\sum_s L_s = L$$  \hspace{1cm} (7)

where $L$ is the national endowment of labour.

Typically, the size of the work force and the population by region will differ. If the total national population is $N$, and the population in region $s$ is $N_s$, then $N = \sum_s N_s$, and the average income in each

\textsuperscript{1}We assume here that labour migrates only in response to its regional wage, not also its proportional share in rents. The model can be recast in this form and different numerical results will apply.
region $s$, $I_s$, is given by
\[ I_s = \frac{I_s}{N_s} = \frac{Y_s}{N_s} = \frac{R_s}{N_s} + \frac{W_s L_s}{N_s}, \quad s = 1, \ldots, S \tag{8} \]
National income $I = \sum_s I_s = \sum_s Y_s$, and national average income, $\bar{I}$, is
\[ \bar{I} = \frac{I}{N} = \frac{\sum_s I_s}{\sum_s N_s} = \frac{\sum_s Y_s}{\sum_s N_s}. \tag{9} \]
The average wage per individual in region $s$ is
\[ \bar{W}_s = \frac{W_s L_s}{N_s}, \quad s = 1, \ldots, S \tag{10} \]
in which case $\bar{I}_s = \frac{R_s}{N_s} + \bar{W}_s$.

We can extend this model to cases where capital is mobile across regions. In the extreme case where all capital is mobile, specialization equilibria can easily occur under elimination of Hukou labour mobility restrictions in which there is no production in some regions. Given that in reality capital refers both to regionally immobile land, and other capital such as equipment and machinery that is mobile in the intermediate term, we use a model extension in which there is both regionally fixed (specific) capital and regionally mobile capital. If we model capital in region $s$ as part fixed and part mobile, then the product production function in each region is of the form
\[ Y_s = A_s K_s^{\beta_s} L_s^{\alpha_s}, \quad s = 1, \ldots, S \tag{11} \]
where $K_s$ refers to mobile capital used in region $s$. Specific factors, including immobile capital, are represented by $A_s$, and $\beta_s + \alpha_s < 1$. In this case, the return of mobile capital will be the same in all regions and equal the marginal value product of capital in the region. This return $B$ is given as
\[ B = \frac{\partial Y_s}{\partial K_s} = \beta_s A_s K_s^{\beta_s - 1} L_s^{\alpha_s}, \quad s = 1, \ldots, S \tag{12} \]
and in equilibrium the market in mobile capital will clear, $\sum_{s=1}^S K_s = K$, where $K$ is the economy wide endowment of mobile capital.

If there are no barriers to labour mobility, the common wage rate $W$ is
\[ W_s = \frac{\partial Y_s}{\partial L_s} = \alpha_s A_s K_s^{\beta_s} L_s^{\alpha_s - 1}, \quad s = 1, \ldots, S \tag{13} \]
and labour market clearing again determines the wage. As before, if there are barriers to mobility then the inter-regional labour allocation no longer corresponds to that supporting a market clearing wage. Removing inter-regional barriers to labour again implies an efficiency gain for the economy as marginal products of labour are equalized across regions, but the size of the gain will differ from the fully capital immobile case. In calibrating such a model we set the total return to both mobile and immobile capital equal to the same total return across to capital under an assumption of fully fixed capital. We then vary the assumed portions of mobile and immobile capital in repeated calculations to explore sensitivity of model results.

If we assume $S = 2$ we can group China in a number of ways which mirror regional classifications of data from Chinese Statistical Yearbooks. There are: urban and rural; rich and poor; eastern coastal
and central and western (non-coastal) zones; eastern and central and western development zones. If
S = 3, we group by eastern, central and western zones. We also consider a 6 region case of Northern
China, Northeastern China, Eastern China, Central and Southern China, Southwestern China, and
Northwestern China. There are 31 provinces, centrally administered municipalities and autonomous
regions in China in total 2 and we also explore a 31 region variant of the model that captures all of
these. Differences in results across these cases reflect the degree and form of regional disaggregation
used in alternative empirical applications of the model.

The models set out above with the two different treatments of capital mobility can be used numerically
to assess the distributional impacts of removing Hukou migration restrictions by first calibrating observed
wage and GDP / capita differences across the various two region divides set out above for China and then
recomputing a counterfactual equilibrium with removal of restrictions. To do this we use a benchmark
data set for a given initial year in the presence of Hukou restrictions on labour mobility, and assess
the implications of removing mobility restrictions given the observed initial differences in GDP / capita
and wage inequality. In the capital immobile case, if Y_s, L_s, and W_s are observed and given by data,
we can use the model in calibration mode and solve the system of 2S equations (3) and (4) for the 2S
unknowns A_s and a_s. We can then compute a counterfactual equilibrium for this simple model in which
W = W_s (s = 1, ⋯, S) and labour mobility restrictions are eliminated. Comparing the original data to
the solution generated as the counterfactual model equilibrium then yields an evaluation of the impacts
of Hukou on both national and regional income inequality in this simple case. A similar approach can
be used in more detailed multi-region calculations and with mobility of a portion of capital where the
rate of return across regions is equalized and the there is full employment of capital.

In Table 1 we report the 2001 base year data used in calibration for the 2, 3, and 6 regions. These
are GDP / capita by region, wage rate differentials across regions work force and population by region.
We assume the ratio of the work force to the population in any region is fixed and when a worker moves
between regions, a corresponding multiple of the population also moves. Data for the full 31 regions
version is available on request. Using these data as an input, through calibration we determine the
model parameters A_s and a_s, as well as regional outputs Y_s^0, rents R_s^0, and other variables I_s^0, I_s^0,
P_s^0, J_s^0, and W_s^0. We assess the impacts of eliminating Hukou restrictions on all endogenous model
variables Y_s, L_s, W_s, R_s, I_s, I, I, J, J, J, W, and solve the model in counterfactual model for the
case where wage rates are equalized across regions and thus determine the migration impacts on work
force and population by region.

2We treat all the provinces, centrally administered municipalities and autonomous regions in China as separate and
distinct entities (provinces) in more detailed regional calculations reported later.
<table>
<thead>
<tr>
<th>Regional Classification&lt;sup&gt;2&lt;/sup&gt; Used in Model Variants</th>
<th>Urban - Rural</th>
<th>Rich - Poor</th>
<th>EC - CW</th>
<th>EC - WD</th>
<th>E - C - W</th>
<th>6 Regions&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;sup&gt;10&lt;/sup&gt;³ RMB)</td>
<td>R 6.05665</td>
<td>P 5.79754</td>
<td>CW 5.79994</td>
<td>WD 5.03428</td>
<td>W 4.94210</td>
<td>NEC 9.93368</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>EC 11.03664</td>
<td>CSC 7.78470</td>
<td>SWC 4.71466</td>
<td>NC 9.43888</td>
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<tr>
<td>(&lt;sup&gt;10&lt;/sup&gt;³ RMB)</td>
<td>R 5.73975</td>
<td>P 6.71116</td>
<td>CW 6.77753</td>
<td>WD 5.99797</td>
<td>W 6.03203</td>
<td>NEC 9.61653</td>
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<td></td>
<td></td>
<td>CSC 8.01842</td>
<td>SWC 6.04259</td>
<td>NWC 6.00533</td>
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<td><strong>Work Force by Region</strong></td>
<td>U 142.236</td>
<td>R 218.465</td>
<td>EC 264.782</td>
<td>EC 447.606</td>
<td>E 264.782</td>
<td>NC 68.458</td>
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<td>(&lt;sup&gt;10&lt;/sup&gt;⁶ Individuals)</td>
<td>R 482.291</td>
<td>P 412.062</td>
<td>CW 365.745</td>
<td>WD 182.861</td>
<td>W 147.294</td>
<td>NEC 45.216</td>
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<td></td>
<td></td>
<td></td>
<td>EC 187.020</td>
<td>SWC 165.539</td>
<td>NWC 41.755</td>
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<td><strong>Population by Region</strong></td>
<td>U 472.39</td>
<td>R 442.38</td>
<td>EC 527.10</td>
<td>EC 903.36</td>
<td>E 527.10</td>
<td>NC 147.35</td>
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<tr>
<td>(&lt;sup&gt;10&lt;/sup&gt;⁶ Individuals)</td>
<td>R 795.63</td>
<td>P 825.45</td>
<td>CW 740.73</td>
<td>WD 364.47</td>
<td>W 292.82</td>
<td>NEC 106.86</td>
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<td></td>
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<td>EC 365.77</td>
<td>SWC 200.86</td>
<td>NWC 91.86</td>
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</tr>
</tbody>
</table>

1. All data are from the Chinese Statistical Yearbook (2002).
2. The regional classifications are presented in more details in Footnote 5 (Page 7).
3. NC, NEC, EC, CSC, SWC, and NWC denote Northern China (5 provinces), Northeastern China (3 provinces), Eastern China (7 provinces), Central and Southern China (6 provinces), Southwestern China (5 provinces), and Northwestern China (5 provinces), respectively.

For the construction of the base year data we have used when calibrating alternative versions of the model we first rank provinces from rich to poor (on an income (GDP) / capita basis), taking the top 10 provinces (approximately 35 % of the population) as the rich group. The remaining provinces make up the poor group. We next group provinces into two eastern coastal and central and southern (non-coastal) provincial groupings, and two eastern and central and western development zones. We also divide the 31 provinces into 3 zones and 6 regions. We finally consider all Chinese provinces in a 31 region version of the model. ³ Since data on Chinese GDP / capita (average income) and wage

<sup>3</sup>There are 31 provinces, centrally administered municipalities and autonomous regions in the Chinese mainland. The 31 provinces, centrally administered municipalities and autonomous regions ranked from rich to poor by GDP per capita are Shanghai, Beijing, Tianjin, Zhejiang, Guangdong, Jiangsu, Fujian, Liaoning, Shandong, Heilongjiang, Hebei, Xinjiang,
differentials are only readily available on a provincial basis, we use data for all 31 provinces, centrally administered municipalities and autonomous regions to group regions in China in various ways. We consider seven different regional divides grouping data on population, output, work force, and wage rate for each.

Table 2 reports results for numerical simulations showing the impacts of Hukou elimination in model variants using alternative Chinese regional divides for the regional specific fixed capital case. The changes reported imply that for the urban-rural 2 region case the per capita income differential falls from 2 : 1 to 7 : 10, while in case two (rich-poor) it falls from over 7 : 3 to 4 : 3. In the urban - rural case, approximately 48% of the work force and 45% of the population move from rural to urban areas after Hukou removal. Around 17% of the population remains in rural areas. They become richer, their average income (GDP per capita) being 1.42 times higher than that in urban areas. Total output increases by about 13%, and GDP per capita and income per worker both increase. In the rich - poor case, there are smaller migration effects after Hukou removal (approximately 25% of the work force and the population move), and total output increases only by about 3.2%. In the other 2 region cases (EC - CW and EC - WD) there are smaller migration effects from Hukou removal, while total output and GDP per capita and income per worker again increase. These smaller effects occur because there is an urban - rural divide within each region, and the main migration effect is urban - rural rather than geographical. In the 3 region E - C - W case there are large migration effects out of the Central - Western and Eastern zones after Hukou removal. Total output increases by about 3.0%. In the 6 region case, migration effects between regions are small, and total output increases by about 1.7%.

Hubei, Jilin, Hainan, Inner Mongolia, Hunan, Qinghai, Hessen, Chongqing, Shanxi, Ningxia, Tibet, Anhui, Jiangsu, Sichuan, Shaanxi, Guangxi, Yunnan, Gansu, Guizhou. The first 10 provinces are grouped as rich. The 21 provinces which follow are grouped as poor. Mainland China is divided into 6 regions as follows; Northern China includes 5 provinces: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia; Northeastern China includes 3 provinces: Liaoning, Jilin, Heilongjiang; Eastern China includes 7 provinces: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong; Central and Southern China includes 6 provinces: Henan, Hunan, Guangdong, Guangxi, Hainan; Southwestern China includes 5 provinces: Chongqing, Sichuan, Guizhou, Yunnan, Tibet; Northwestern China includes 5 provinces: Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang. The Eastern Coastal zone includes 12 provinces: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan. The Central zone includes 9 provinces: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan. The Western zone includes 10 provinces: Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang. The Western Development zone includes 12 provinces as Inner Mongolia, Guangxi, and western zone. In Tables 2 and 3 and in the discussion that follows, EC - CW zones denote Eastern Coastal zone - Central and Western zones, EC - WD zones denote Eastern and Central zone - Western Development zone, E - C - W zones denote Eastern zone - Central zone - Western zone.
### Table 2. Impacts of Hukou Elimination in Alternative Regional Divides in Fixed Capital Version of Inter-regional Labour Mobility Model for China
(Changes Relative to Base Case Data for 2001)

<table>
<thead>
<tr>
<th></th>
<th>Urban - Rural</th>
<th>Rich - Poor</th>
<th>EC - CW</th>
<th>EC - WD</th>
<th>E - C - W</th>
<th>6 Regions</th>
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<tr>
<td>Change in Value of Output (10^6 RMB)</td>
<td>U 382.041</td>
<td>R 182.917</td>
<td>EC 1243.425</td>
<td>EC 884.753</td>
<td>E 1242.262</td>
<td>NC 209.063</td>
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<td></td>
<td>N 1414.187</td>
<td>N 342.831</td>
<td>N 240.161</td>
<td>N 183.267</td>
<td>N 324.537</td>
<td>NWC -137.214</td>
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<td></td>
<td>U -3.49215</td>
<td>R -4.88382</td>
<td>EC -2.55705</td>
<td>EC -0.98651</td>
<td>E -2.54224</td>
<td>NC -1.27485</td>
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<td></td>
<td>R 6.5073</td>
<td>P 1.33713</td>
<td>CW 1.62269</td>
<td>WD 1.94103</td>
<td>C 0.82027</td>
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<td>N 1.1544</td>
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<td>NEC 21.482</td>
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<td>Change in Average Income per capita (10^3 RMB)</td>
<td>U -18.72939</td>
<td>R -7.30444</td>
<td>EC -5.62016</td>
<td>EC -2.02573</td>
<td>E -5.01631</td>
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<td>R 5.22525</td>
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<td>CW 2.52885</td>
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<td>N 2.2487</td>
<td>N 0.54372</td>
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<td>CSC 0.26247</td>
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<td>Change in Wage Rate (10^3 RMB)</td>
<td>U -7.89761</td>
<td>R -2.56994</td>
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<td>EC -0.50160</td>
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<td>R 1.00169</td>
<td>P 2.03028</td>
<td>CW 1.96391</td>
<td>WD 2.74347</td>
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<td>N -0.88978</td>
<td>N 0.54372</td>
<td>N 0.38089</td>
<td>N 0.20602</td>
<td>N 0.41955</td>
<td>EC -1.08238</td>
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<td>Change in Work Force by Region (Migration) (millions of individuals)</td>
<td>U 302.81913</td>
<td>R 158.40700</td>
<td>EC 135.07144</td>
<td>EC 101.17314</td>
<td>E 134.93051</td>
<td>NC 23.54375</td>
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<td></td>
<td>R -302.81913</td>
<td>P -158.40700</td>
<td>CW -135.07144</td>
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<td>W -81.60556</td>
<td>W 2.70943</td>
<td>W 2.70943</td>
<td>W 2.70943</td>
<td>W 2.70943</td>
<td>NW C -72.9797</td>
</tr>
<tr>
<td>Change in Population by Region (Migration) (millions of individuals)</td>
<td>U 579.01525</td>
<td>R 318.69952</td>
<td>EC 271.82881</td>
<td>EC 201.97491</td>
<td>E 270.40651</td>
<td>NC 49.40968</td>
</tr>
<tr>
<td></td>
<td>R -579.01525</td>
<td>P -318.69952</td>
<td>CW -271.82881</td>
<td>WD -201.97491</td>
<td>C -106.54838</td>
<td>NEC 5.63122</td>
</tr>
<tr>
<td></td>
<td>W -161.92568</td>
<td>W 2.70943</td>
<td>W 2.70943</td>
<td>W 2.70943</td>
<td>W 2.70943</td>
<td>SWC -124.04133</td>
</tr>
<tr>
<td></td>
<td>N -43.61816</td>
<td>N 2.70943</td>
<td>N 2.70943</td>
<td>N 2.70943</td>
<td>N 2.70943</td>
<td>NW C -43.61816</td>
</tr>
</tbody>
</table>
The picture that emerges from Table 2 is that Hukou registration is a significant policy impediment preventing the achievement of a more equal distribution of incomes and wages in China. The number of people who would migrate across regions after its removal in the first 4 cases is 600 million people (\( \frac{1}{2} \) of the population of China). Unlike the international migration case where Hamilton and Whalley (1984) found very large efficiency effects due to larger initial wage dispersion, the efficiency effects gains are more modest but still significant. The gain is 13\% of national output in the first case, and considerably smaller at 1.7\% - 3.2\% in the other three geographical divide cases. In each case wage differentials across regional divides are eliminated with the removal of Hukou restrictions, and average incomes across regions are more closely equalized. The differences that remain in average incomes are due to differences in rents across regions.

Table 3 reports a more detailed 31 region calculation using the model. Compared to the small dimensional geographical divides results showing gain of 1.7 to 3\% of GDP, an increase in output of around 7\% results, and differentials in both GDP / capita and income per worker across regions are sharply narrowed. The direction of migration is from poor to rich provinces, that is, from Henan, Guizhou, Sichuan, Anhui, Guangxi, Yunnan, Shaanxi, Gansu, Hunan, Chongqing, Jiangxi, Hebei, Shanxi to Guangdong, Shanghai, Beijing, Zhejiang, Jiangsu, Fujian, Tianjin. The overall picture conveyed by these results is that removal of Hukou registration plays a more major role in reducing relative income inequality in China in a more disaggregated model calculation.

Table 4 reports results both for versions of the model incorporating differing degree of capital mobility. As explained above, fully capital mobility is not consumed since in this case specialization equilibrium can occur in the model. As the portion of capital assumed mobile increase from 0 (the same as Table 3) to 75 \%, the national gain increases and more labour moves between regions. Within 75 \% of capital mobile the gain rise to 24 \% of GDP; some 70 \% larger the fixed capital case. These results occur because as labour leaves rural areas as Hukou restrictions are removed, this raises the marginal product of capital in the receiving region and capital also moves. This in turn raises further the marginal product of labour in the receiving region and more labour moves. Factor flows between regions in this model are thus complementary to one another, even though factors are substitutes in production. These results as a set thus indicate that estimates of gains from elimination of Hukou restrictions while sensitive to assumptions on capital mobility still remain large, and that elimination of Hukou restrictions will have a significant and positive effect on national inequality.
Table 3. National Gain and Migration under Hukou Elimination
For More Detailed Regional Groupings in the Model

<table>
<thead>
<tr>
<th></th>
<th>2 Region EC - CW Model</th>
<th>2 Region EC - WD Model</th>
<th>2 Region E - C - W Model</th>
<th>6 Regions Model</th>
<th>31 Provinces Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Gain from Removal of Hukou Restrictions as % of GDP</td>
<td>2.25110</td>
<td>1.71781</td>
<td>3.04198</td>
<td>1.68320</td>
<td>6.92509</td>
</tr>
<tr>
<td>Work Force Migration (Million)</td>
<td>135.07144</td>
<td>101.17314</td>
<td>134.93051</td>
<td>134.93051</td>
<td>175.60454</td>
</tr>
</tbody>
</table>

Table 4. Impacts of Hukou Elimination With Partial Capital Mobility Between Regions in 2 Region (Urban - Rural Divide) Model

<table>
<thead>
<tr>
<th>Portion of Capital in Each Region Assumed Mobile</th>
<th>National Gain from Removal of Hukou Restriction as % of GDP</th>
<th>Urban-Rural Change Work Force Migration (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>13.25557</td>
<td>302.81913</td>
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<tr>
<td>0.25</td>
<td>15.13008</td>
<td>343.56609</td>
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<td>0.30</td>
<td>15.63167</td>
<td>353.91916</td>
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<tr>
<td>0.35</td>
<td>16.19068</td>
<td>365.14706</td>
</tr>
<tr>
<td>0.40</td>
<td>16.81720</td>
<td>377.28546</td>
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<tr>
<td>0.45</td>
<td>17.52169</td>
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</tr>
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<td>0.50</td>
<td>18.31692</td>
<td>404.21656</td>
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<td>0.65</td>
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<td>0.70</td>
<td>22.69865</td>
<td>461.17796</td>
</tr>
<tr>
<td>0.75</td>
<td>24.15291</td>
<td>471.76949</td>
</tr>
</tbody>
</table>
3 Extending the Model to Capture House Price Effects on Migration Across Regions

A key feature of the urban-rural divide in modern day China missing in the model variants discussed above is large differences in housing (apartment) prices between the larger cities and village communities. Apartments in Beijing routinely sell for US $100,000, and with average annual household incomes of around US $2,000 in the Beijing area, even at 5% the imputed income on apartments owned outright can be larger than annual cash income. Thus, households who received apartments at low (or zero) prices in urban areas in the late 1980’s or the early 1990’s have a large advantage over rural dwellers who might wish to move to the cities following a removal of Hukou restrictions. In this case the effect of added inward migration will be to drive up urban house prices further and this house price effect will act to dampen additional migration. Less migration following Hukou elimination appears in models incorporating house price effects in contrast to models which do not incorporate them; but working with them involves the use of a more complex analytical structure.

We have modified the basic capital immobile model set out in Section 2 to also incorporate house price effects stemming from additional urban-rural migration. We consider the 2 region urban-rural divide. We capture impacts of urban house prices on urban-rural mobility decisions by using a general equilibrium model with goods and housing separately identified, and with housing prices in urban and rural areas differing reflecting market segmentation due to location. In this case, removing Hukou restrictions generates labour flows from rural to urban areas, but when these are included increases in urban house prices retard additional migration. Labour flows under Hukou removal are smaller and significant further redistribution occurs between urban dwellers whose house prices rise and rural dwellers whose prices fall. Efficiency gains from Hukou removal will tend to be smaller in models with house price effects since the number of migrants will be smaller.

We can present this model variant more formally as follows. We once again denote $L_s$ as the labour in region $s$ before Hukou removal. The regional production functions are again

$$Y_s = A_s L_s^{\alpha_s}, \quad s = U, R$$

and the regional wage rates, $W_s$, are given as

$$W_s = P_G \frac{\partial Y_s}{\partial L_s} = P_G \alpha_s A_s L_s^{\alpha_s - 1}, \quad s = U, R$$

where $P_G$ is the goods price, and regional rents, $R_s$, are

$$R_s = P_G Y_s - W_s L_s, \quad s = U, R.$$

Income in region $s$ is $I_s$

$$I_s = P_G Y_s, \quad s = U, R.$$  

(17)

National income is $I = \sum_s I_s$. Full employment of labour in this model again implies that

$$\sum_s L_s = L.$$  

(18)
where $L$ is the national endowment of labour.

We assume that there is continuum of individuals who vary in terms of their preferences towards goods and housing and who are uniformly distributed over a unidimensional interval $[t_R, t_U]$ for a parameter $t$. $t$ is a Cobb-Douglas preference function parameter varying across all individuals. $t$ is the critical value of the preference parameter such that urban individuals all have $t$ values above $\bar{t}$ and lie on the interval $[\bar{t}, t_U]$ and rural individuals all have $t$ values below $\bar{t}$ and lie on the interval index $[t_R, \bar{t}]$. The continuum of individuals $[t_R, t_U]$ are assumed to differ in preference shares parameters for Cobb-Douglas preferences defined as

$$V_t(G, H) = G^{1-t}H^t, \quad t \in [t_R, t_U]$$

where $G$ is consumption of goods, and $H$ is consumption of housing.

We assume for simplicity that all individuals in urban and rural areas have endowments of housing $E_U$ and $E_R$ that are similar in structure, but differ in size. Their incomes are

$$I^U_t = R_U X^U_t + W_U L_U X^U_t + P_U E_U X^U_t = (P_G Y_U + P_U E_U)X^U_t, \quad t \in [\bar{t}, t_U]$$

$$I^R_t = R_R X^R_t + W_R L_U X^R_t + P_R E_R X^R_t = (P_G Y_R + P_R E_R)X^R_t, \quad t \in [t_R, \bar{t}]$$

where $X^U$ and $X^R$ are uniform distribution random variable on $[\bar{t}, t_U]$ and $[t_R, \bar{t}]$.

Utility maximization subject to a budget constraint in each case implies

$$G^U_t = \frac{1-t}{P_U} I^U_t \quad \text{and} \quad H^U_t = \frac{t}{P_U} I^U_t, \quad t \in [\bar{t}, t_U]$$

$$G^R_t = \frac{1-t}{P_R} I^R_t \quad \text{and} \quad H^R_t = \frac{t}{P_R} I^R_t, \quad t \in [t_R, \bar{t}]$$

A general equilibrium in this model involves an equilibrium value $\bar{t}$, and the division of the population into urban and rural components is endogenously determined. Before Hukou removal an equilibrium is characterized by wage rates $W_s$, a goods price $P_G$, urban and rural house prices $P_U$ and $P_R$ such that the following conditions hold:

1. (Good Market Clearing) $Y_U + Y_R = \int_{\bar{t}}^{t_U} G^U_t dt + \int_{\bar{t}}^{t_R} G^R_t dt$;
2. (House Market Clearing) $\int_{\bar{t}}^{t_U} H^U_t dt = E_U$ and $\int_{\bar{t}}^{t_R} H^R_t dt = E_R$;
3. (Labour Market Clearing) $L_U + L_R = L$;

If we consider the case of Hukou removal, under the assumption that all individuals have identical amounts of labour in urban and rural areas, then labour is allocated by region such that

$$L_U = \frac{t_U - \bar{t}}{t_U - t_R} L \quad \text{and} \quad L_R = \frac{\bar{t} - t_R}{t_U - t_R} L.$$ 

After Hukou removal we need to add a migration equilibrium condition involving a money metric measure of the relative valuation of a unit of income across the two regions $\frac{TCL(U, \bar{t})}{TCL(R, \bar{t})}$, where $TCL$ refers to the true cost of living index. This term reflects the different price levels across the two regions due to different housing prices. As TCL indices enter when making migration decisions, individuals take into account not only wage rate differences across regions, but also the different cost of housing.
To construct this metric we use the indirect utility functions

\[ V_t(t^U) = \left(1 - \frac{t}{P_G}\right)^{1-t} \left(\frac{t}{P_U}\right)^t I_t^U, \quad t \in [t, t_U] \quad (25) \]

\[ V_t(t^R) = \left(1 - \frac{t}{P_G}\right)^{1-t} \left(\frac{t}{P_R}\right)^t I_t^R, \quad t \in [t_R, \hat{t}] \quad (26) \]

for which the TCL indices are

\[ TCL(U, t) = \left[\left(\frac{1-t}{P_G}\right)^{1-t} \left(\frac{t}{P_U}\right)^t\right]\left[\left(\frac{1-t}{P_G}\right)^{1-t} \left(\frac{t}{P_R}\right)^t\right]^{-1}, \quad t \in [t, t_U] \quad (27) \]

\[ TCL(R, t) = \left[\left(\frac{1-t}{P_G}\right)^{1-t} \left(\frac{t}{P_R}\right)^t\right]\left[\left(\frac{1-t}{P_G}\right)^{1-t} \left(\frac{t}{P_R}\right)^t\right]^{-1}, \quad t \in [t_R, \hat{t}] \quad (28) \]

The equilibrium condition that migration must satisfy changes from the model with house price effects is

\[ \frac{W_U}{W_R} = \frac{TCL(U, \hat{t})}{TCL(R, \hat{t})} = \left[\frac{P_U}{P_R}\right]^i. \quad (29) \]

A general equilibrium after Hukou removal is thus given by the critical value of the share parameter \( t \), wage rates \( W_w \), a goods price \( P_G \), and urban and rural house prices \( P_U \) and \( P_R \) such that the following conditions hold.

[1] (Good Market Clearing) \( Y_U + Y_R = \int_{t_U}^{t} G^U_t dt + \int_{t_1}^{t} G^R_t dt; \)

[2] (House Market Clearing) \( \int_{t_U}^{t} H^U_t dt = E_U \) and \( \int_{t_R}^{t} H^R_t dt = E_R; \)

[3] (Labour Market Clearing) \( L_U + L_R = L; \)

[4] (Migration Condition) \( \frac{W_U}{W_R} = \left[\frac{P_U}{P_R}\right]^i. \)

The general equilibrium conditions [2] can be written as

\[ E_U = \int_{t_U}^{t} H^U_t dt = \int_{t_1}^{t} \frac{t}{P_U} I^U_t dt = \int_{t_U}^{t} \frac{t}{P_U} (P_G Y_U + P_U E_U) X^U_t dt = \frac{P_G Y_U + P_U E_U}{P_U} \int_{t_U}^{t} t X^U_t dt \]

\[ P_U E_U = \frac{1}{2}(t_U + \hat{t})(P_G Y_U + P_U E_U) \quad \text{and} \quad P_U E_U = \frac{1}{2}(t_U + \hat{t})P_G Y_U \quad (30) \]

and

\[ E_R = \int_{t_R}^{t} H^R_t dt = \int_{t_R}^{t} \frac{t}{P_R} I^R_t dt = \int_{t_1}^{t} \frac{t}{P_R} (P_G Y_R + P_R E_R) X^R_t dt = \frac{P_G Y_R + P_R E_R}{P_R} \int_{t_R}^{t} t X^R_t dt \]

\[ P_R E_R = \frac{1}{2}(t_R + \hat{t})(P_G Y_R + P_R E_R) \quad \text{and} \quad P_R E_R = \frac{1}{2}(t_R + \hat{t})P_G Y_U \quad (31) \]

The general equilibrium condition [1] holds from equations (30) and (31).

We use this model to explore the dampening effect of house price rises on migration by comparing the induced migration from Hukou elimination across two model variants. One of these captures house price effects, and the second does not. The latter model is structurally the same as the basic model in the preceding section, but is calibrated to different data which removes housing expenditures from GDP
(and hence is smaller than GDP data used in the previous section) to make the data used in the with and without house price effect models comparable.

To implement these two models we again calibrate to base case data for 2001 and consider Hukou removal. From Chinese Statistical yearbook (2002) urban and rural non housing GDP in 2001 are 5849.777 million RMB and 4818.849 million RMB. If we assume the shares of housing / apartments in GDP in urban and rural areas to be 22.50 % and 18.50 %, \(^4\) then the base case value of the endowments of housing are 1316.200 and 891.487. The consumption value of non housing goods in the urban and rural areas is \(4533.577 (= 5849.777 - 1316.200)\) and \(3927.362 (= 4818.849 - 891.487)\). Urban and rural labour are 148.236 and 482.291, and wage rates are 16.638 and 5.740. Rents are 2067.219 (= 4533.577 - 16.638 \times 148.236) and 1159.132 (= 3927.362 - 5.740 \times 482.291).

For the model which excludes housing price effects, we use the same model as in Section 2 to analyze the effects of Hukou removal, but only focus on the non-housing portion of the economy which is smaller. Through calibration data we compute the scale and share parameters in production as \(A_U = 298.8121\) and \(A_R = 50.4371\), \(\alpha_U = 0.5440\) and \(\alpha_R = 0.7049\). Equilibrium outcomes after Hukou removal are output: \(Y_U = 9116.090\) and \(Y_R = 1251.721\), work force: \(L_U = 535.296\) and \(L_R = 95.231\), common wage rate: \(W_U = W_R = 9.265\). Labour migration under Hukou removal is \(= 535.296 - 148.236 = 482.291 - 95.231 = 387.060\).

To evaluate the impacts of Hukou removal in the presence of house price effects, we use the model above and compare model results without and with house price effects. We assume equilibrium prices in the base case are \(P_G = 1\), \(P_U = 1\) and \(P_R = 1\). \(Y_U = 4533.577\) and \(Y_R = 3927.362\), \(E_U = 1316.200\) and \(E_R = 891.487\), \(L_U = 148.236\) and \(L_R = 482.291\), \(W_U = 16.638\) and \(W_R = 5.740\), \(R_U = 2067.219\) and \(R_R = 1159.132\), \(I_U = 4533.577\) and \(I_R = 3927.362\). Calibration yields the scale and share parameters as \(A_U = 298.8121\) and \(A_R = 50.4371\), \(\alpha_U = 0.5440\) and \(\alpha_R = 0.7049\).

In this case if we assume \(\tau_U = 0.2344\) and \(\tau_R = 0.1544\), this implies a value of \(\tilde{t} = 0.2156\), which is consistent with the proportion of the population in urban and rural areas in base case data and given by \(\frac{Y_U - \tilde{t}}{Y_U - \tilde{t}}\) and \(\frac{\tilde{t} - \tau_R}{\tilde{t} - \tau_R}\). This implies \(\int_{t}^{\tilde{t}} U^t \frac{dt}{U^t - \tilde{t}}\) and \(\int_{\tau_R}^{\tilde{t}} U^t \frac{dt}{U^t - \tilde{t}}\). This implies \(\int_{t}^{\tilde{t}} U^t \frac{dt}{U^t - \tilde{t}} = 5849.777\) and \(\int_{\tau_R}^{\tilde{t}} U^t \frac{dt}{U^t - \tilde{t}} = 4818.849\). Then \(\int_{\tau_R}^{\tilde{t}} G^t \frac{dt}{G^t} = 4533.577\) and \(\int_{\tau_R}^{\tilde{t}} H^t \frac{dt}{H^t} = 1316.200\). \(\int_{t}^{\tilde{t}} G^t \frac{dt}{G^t} = 3927.362\) and \(\int_{\tau_R}^{\tilde{t}} H^t \frac{dt}{H^t} = 891.487\).

To analyze Hukou removal in this case, in the base case \(t_U = 0.2344\) and \(\tau_R = 0.1544\), this implies a new equilibrium value of \(\tilde{t} = 0.1760\). The equilibrium prices are \(P_G = 1.000\), \(P_U = 1.647\) and \(P_R = 0.419\). Other variables are \(Y_U = 8394.802\) and \(Y_R = 1887.051\), \(L_U = 460.035\) and \(L_R = 170.492\), \(W_U = 9.927\) and \(W_R = 7.802\), \(R_U = 3827.859\) and \(R_R = 556.949\), \(I_U = 8394.802\) and \(I_R = 1887.051\). \(\int_{\tau_R}^{\tilde{t}} U^t \frac{dt}{U^t - \tilde{t}} = 4536.240\) and \(\int_{\tau_R}^{\tilde{t}} U^t \frac{dt}{U^t - \tilde{t}} = 2260.536\). Under Hukou elimination \(\int_{t}^{\tilde{t}} G^t \frac{dt}{G^t} = 8394.802\) and \(\int_{\tau_R}^{\tilde{t}} H^t \frac{dt}{H^t} = 2167.617\). \(\int_{\tau_R}^{\tilde{t}} G^t \frac{dt}{G^t} = 1887.051\) and \(\int_{\tau_R}^{\tilde{t}} H^t \frac{dt}{H^t} = 373.485\). Labour migration under Hukou removal in this case is \(= 460.035 - 148.236 = 482.291 - 170.492 = 311.799\) and the efficiency gain from elimination of Hukou restrictions is \(= 12822.955 - 10068.626 = 2154.329\). Rising house prices thus serve to dampen migration relative to the 387.05 value from the comparable no house price rise model. The

\(^4\) See the discussion in Wang and Zuo (1999) which from a reading supports estimates of this size for the mid 1990’s appealing to survey evidence from various sources.
size of efficiency gains is also reduced.
4 A Model with a Distribution of Productivities within Regions

The model set out above can also be elaborated on to also incorporate within region efficiency (or productivity) differences across individuals and hence inequality within regions both before and after the elimination of Hukou. This also allows us to calibrate the model not only to wage differentials across regions, but also to urban and rural Gini coefficients. With these features present, wage differentials across individuals will not disappear with the elimination of Hukou restrictions as in the basic model presented above. We limit our discussion of this case to the model from where capital is fully immobile across regions.

Table 5 reports estimates of urban, rural and national household income Gini coefficients from Chang (2002) which show how income inequality has changed China over the last 20 or so years. This is representative of data claimed to show the growing income divide in China (but see the earlier footnote 1 on the implications of alternative data for recent year). At national level there is consistent worsening of national inequality which is seemingly always more unequal than regional inequality (as measured by the Gini coefficient). In our base case data we use Gini coefficients for urban - rural, rich - poor, EC - CW, EC - WD, E - C - W, and NC - NEC - EC - CSC - SWC - NWC for 2001 reported in Chinese People Daily (November 4, 2003 and March 30, 2004) which are close to Chang’s 2002 estimates. These are displayed later in Table 6.

To incorporate efficiency differences across individuals within regions into the model we use a functional form for the distribution of incomes within regions which through calibration implies a distribution of the efficiencies of labour across individuals within a region. This approach allows us to specify initial differences in efficiencies across all individuals in specific regions of the economy so as to also calibrate a modified version of the simple model to within region inequality as measured by Gini coefficients for each region, as well as to a national Gini inequality measure of income inequality. In this model variant removing labour mobility restrictions once again equalizes wage rates per efficiency unit of labour across regions, but with differing endowments of efficiency units of labour across individuals wage rate inequality will remain both across individuals and across regions when Hukou restrictions are removed. An elimination of Hukou restrictions will be equalizing, but compete equality of wage rates across individuals within regions will not be achieved as efficiency differences remain.

We assume that when mobility of labour occurs across regions, labour moves in the form of a representative portion or slice of the distribution of productivities. This departs the leaving region, and adding itself proportionally to the distribution of productivities in the receiving region. This is a treatment that simplifies the analysis, and leaves the within region distribution of productivities unchanged in both migrating and receiving regions as mobility occurs. The regional income distribution changes however, because of the presence of region specific rents.
Table 5. Regional and National Gini Coefficients for Household Income in China from 1978 to 2000

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban Areas</th>
<th>Rural Areas</th>
<th>Nation</th>
</tr>
</thead>
<tbody>
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<td>1979</td>
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<td>0.300</td>
<td>0.321</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>0.250</td>
<td>0.342</td>
<td>0.400</td>
</tr>
<tr>
<td>1995</td>
<td>0.280</td>
<td>0.323</td>
<td>0.415</td>
</tr>
<tr>
<td>1996</td>
<td>0.290</td>
<td>0.329</td>
<td>0.424</td>
</tr>
<tr>
<td>1997</td>
<td>0.300</td>
<td>0.337</td>
<td>0.425</td>
</tr>
<tr>
<td>1998</td>
<td>0.295</td>
<td>0.336</td>
<td>0.456</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td>0.457</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.320</td>
<td>0.458</td>
<td></td>
</tr>
</tbody>
</table>

Source: Chang (2002)

The model we use for this case can be formally stated as follows. The same equations (3) - (7) characterize the production side of the model, but there are now also distributions of income within regions which reflect differences in the efficiency of labour within regions. Denoting $N_s$ as the number of people in region $s$, and $L_s$ as labour in efficiency units in region $s$ ($N_s \neq L_s$), we have average regional incomes $\bar{I}_s$, national income $\overline{I}$, average national income $\bar{I}$, and the average region wage $\bar{W}_s$ as in (8) - (10) above.

The functional form for the income distribution within each region $s$ can take many forms. We assume the non-linear form

$$I^n_s = C_s + D_s n + E_s n^g, \quad n = 1, \cdots, N_s, \quad s = 1, \cdots, S. \quad (32)$$
where \( n \) is an index \( 1, \ldots, N_s \) across the individuals \( N_s \) in regions ranked from poor to rich, and \( C_s, D_s, E_s \) and \( \delta_s \) are parameters of the distribution function. This provides sufficient free parameters to calibrate the model to both regional and national Gini coefficients through a generated distribution of efficiencies. We could alternatively use a functional form from the class used in distributional literature such as a Pareto distribution, although the implied distribution of efficiencies would not be Pareto. If a simple linear form were used there would not be sufficient free parameters for calibration.

Using (32), we calibrate the model to satisfy \( 2S + 1 \) conditions reflecting total income and Gini coefficient constraints and in addition use the same calibration conditions for the simple model above. Since

\[
I_s = \sum_{n=1}^{N_s} I^n_s = \sum_{n=1}^{N_s} [C_s + D_s n + E_s n^\delta], \quad s = 1, \ldots, S,
\]

\[
G_s = \frac{1}{2N_s^2 I_s} \sum_{n=1}^{N_s} \sum_{n'=1}^{N_s} |I^n_s - I^{n'}_s| = 1 - \frac{1}{N_s^2 I_s} \sum_{n=1}^{N_s} \sum_{n'=1}^{N_s} \min\{I^n_s, I^{n'}_s\}, \quad s = 1, \ldots, S
\]

where \( G_s \) is the region \( s \) Gini coefficient in incomes.\(^5\)

The national Gini coefficient, \( g \), is given by

\[
G = \frac{1}{2N^2 T} \left\{ \sum_{s=1}^{S} \sum_{n=1}^{N_s} \sum_{n'=1}^{N_s} |I^n_s - I^{n'}_s| + 2 \sum_{s \neq s'} \sum_{n=1}^{N_s} \sum_{n'=1}^{N_{s'}} \min\{I^n_s, I^{n'}_{s'}\} \right\} = 1 - \frac{1}{N^2 T} \left\{ \sum_{s=1}^{S} \sum_{n=1}^{N_s} \sum_{n'=1}^{N_s} \min\{I^n_s, I^{n'}_s\} + 2 \sum_{s \neq s'} \sum_{n=1}^{N_s} \sum_{n'=1}^{N_{s'}} \min\{I^n_s, I^{n'}_{s'}\} \right\}
\]

One difficulty in implementing this model variant is that initial data on regional and national Gini coefficients and estimates of regional and national GDP / capita can be mutually inconsistent. Where this occurs, we have adopted a procedure of accepting data on regional and a national GDP / capita, and accepting one or more of the Gini coefficient estimates for 2001 and setting remaining Gini coefficients at bounds implied by mutual consistency requirements. In the main, these are close to the available literature estimates, but do depart from these slightly. No other procedure short of modifying other portions of input data seems to suggest itself.

For the urban - rural case above where \( S = 2 \), \( I_U = 5849.777 \), \( I_R = 4818.847 \) and \( I = 10668.626 \) from Section 2. If the three Gini coefficients (drawing on Chang (2002)) are set as \( G_U = 0.3200 \), \( G_R = 0.3500 \) and \( G = 0.4600 \), and these are used as inputs into calibration. This allows us to calibrate the model for \( S(= 4 \times 2) \) unknown distribution function parameters: \( C_s, D_s, E_s \), and \( \delta_s \). If we then remove Hukou restrictions and compute a new model solution the three computed Gini coefficients reported on Table 5 are \( G_U = 0.3572 \), \( G_R = 0.3687 \) and \( G = 0.3705 \). Compared to the case of the simple model, the impact on inequality of Hukou removal is smaller, but it is still significant and especially so for national inequality.

For the rich - poor case above \( S \) also equals 2, and \( I_R = 5883.043 \) and \( I_P = 4785.583 \), \( I = 10668.626 \) (from Section 2). Drawing on Liu, Yao and Zhang (2001) we set the three Gini coefficients to be \( g_R = 0.4094 \), \( g_P = 0.2030 \), and \( g = 0.4600 \). We again calibrate the model and compute the \( S(= 4 \times 2) \)

\(^5\)See Sen (1972)
unknown parameters: $C_s, D_s, E_s,$ and $\delta_s$ for $s = R, P,$ and remove Hukou restrictions computing a new model solution. The three Gini coefficients in this solution are $G_R = 0.4236$, $G_P = 0.1692$, and $G = 0.3739$.

Impacts on inequality in this case are smaller compared to the simple model but still significant. Impacts on the three Gini coefficients differ from the urban - rural case because the initial dispersion in Gini coefficients is larger. For the eastern coastal - central and western case again $S = 2$, $I_{EC} = 6372.436$, $I_{CW} = 4296.190$ and $I = 10668.626$ from Section 2. Appealing again Liu, Yao and Zhang (2001) we now set the three Gini coefficients as $G_{EC} = 0.4119$, $G_{CW} = 0.2040$ and $G = 0.4600$. Using these, we can again calibrate the model and remove Hukou restrictions. The three new Gini coefficients are $G_{EC} = 0.3979$, $G_{CW} = 0.1123$, and $G = 0.3470$. For the eastern central - western development 2 region case, $I_{EC} = 8833.782$, $I_{WD} = 1844.844$ and $I = 10668.626$. The three Gini coefficients are set as $G_{EC} = 0.4186$, $G_{WD} = 0.1600$ and $G = 0.4600$. Removing Hukou restrictions gives the three Gini coefficients $G_{EC} = 0.2244$, $G_{WD} = 0.1813$, and $G = 0.2291$.

We have consolidated these results into a single Table (Table 5) which reports base case and counterfactual Gini coefficients for this extended model applied to four alternative regional divides (urban - rural, rich - poor, and eastern coastal - central and western provinces). We also report summary statistics of both regional and national inequality based on the Theil measure (see Theil 1967) since this is a decomposable measure. Impacts of Hukou removal on inequality as represented by the Gini coefficients are significant. Using both Gini coefficients and Theil measures, national inequality is reduced, but inequality can either worsen or improve at a regional level. In the departing region, inequality typically improves due to the equal distribution of rents. It can however change the other way due to wage change which affects the relative size of wage income and rents. Impacts on inequality are reduced relative to the simple model set out above since the dispersion in efficiencies across individuals implies that some inequality in wage rates remains after Hukou removal.

We also report Theil measures for within and between region inequality before and after Hukou removal. The national Theil measure is

$$T = \frac{1}{N} \sum_{n=1}^{N} I_n \log \frac{I_n}{T}$$

(36)

where $T_s$ is the Theil measure in region $s$. It can also be written in additive form across the measures for each regions

$$T = \sum_{s=1}^{S} T_s \frac{N_s I_s}{NT} + \sum_{s=1}^{S} \frac{N_s I_s}{NT} \log \frac{I_s}{T}$$

(37)

The two terms in right hand side of (37) are within and between Theil measures.

The majority of inequality is within region inequality, and this increases as Hukou restrictions are removed. Across region inequality falls sharply reducing national inequality. This is made clear by the decomposition results reported in Table 6.
6.1 Regional and National Gini Coefficients

<table>
<thead>
<tr>
<th>Urban - Rural</th>
<th>Rich - Poor</th>
<th>EC - CW</th>
<th>EC - WD</th>
<th>E - C - W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gini Coefficients before Hukou Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( G_U ) = 0.3200</td>
<td>( G_R ) = 0.4094</td>
<td>( G_{EC} ) = 0.4119</td>
<td>( G_{EC} ) = 0.4186</td>
<td>( G_E ) = 0.4226</td>
</tr>
<tr>
<td>( G_R ) = 0.3500</td>
<td>( G_P ) = 0.2030</td>
<td>( G_{CW} ) = 0.2040</td>
<td>( G_{WD} ) = 0.1600</td>
<td>( G_C ) = 0.1440</td>
</tr>
<tr>
<td>( G ) = 0.4600</td>
<td>( G ) = 0.4600</td>
<td>( G ) = 0.4600</td>
<td>( G ) = 0.4600</td>
<td>( G ) = 0.4600</td>
</tr>
<tr>
<td>Gini Coefficients after Hukou Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( G_U ) = 0.357188</td>
<td>( G_R ) = 0.423638</td>
<td>( G_{EC} ) = 0.397921</td>
<td>( G_{EC} ) = 0.224439</td>
<td>( G_E ) = 0.254828</td>
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<tr>
<td>( G_R ) = 0.368747</td>
<td>( G_P ) = 0.169154</td>
<td>( G_{CW} ) = 0.112343</td>
<td>( G_{WD} ) = 0.181277</td>
<td>( G_C ) = 0.180328</td>
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<tr>
<td>( G ) = 0.370538</td>
<td>( G ) = 0.373878</td>
<td>( G ) = 0.347042</td>
<td>( G ) = 0.229139</td>
<td>( G ) = 0.259639</td>
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</tbody>
</table>

6.2 Theil Measures of Inequality

<table>
<thead>
<tr>
<th>Urban - Rural</th>
<th>Rich - Poor</th>
<th>EC - CW</th>
<th>EC - WD</th>
<th>E - C - W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theil Measures before Hukou Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( T_U ) = 0.171850</td>
<td>( T_R ) = 0.291932</td>
<td>( T_{EC} ) = 0.285837</td>
<td>( T_{EC} ) = 0.173458</td>
<td>( T_E ) = 0.122389</td>
</tr>
<tr>
<td>( T_R ) = 0.203112</td>
<td>( T_P ) = 0.078384</td>
<td>( T_{CW} ) = 0.102791</td>
<td>( T_{WD} ) = -0.118314</td>
<td>( T_C ) = -0.075694</td>
</tr>
<tr>
<td>( T^1_w ) = 0.185971</td>
<td>( T_w ) = 0.196142</td>
<td>( T_w ) = 0.212126</td>
<td>( T_w ) = 0.123277</td>
<td>( T_w ) = 0.043293</td>
</tr>
<tr>
<td>( T_b ) = 0.064300</td>
<td>( T_b ) = 0.084295</td>
<td>( T_b ) = 0.065885</td>
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<tr>
<td>( T ) = 0.250270</td>
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<td>( T ) = 0.278010</td>
<td>( T ) = 0.158318</td>
<td>( T ) = 0.113015</td>
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<tr>
<td>Theil Measures after Hukou Removal</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>( T_U ) = 0.224532</td>
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<td>( T_{EC} ) = 0.096899</td>
<td>( T_E ) = 0.136043</td>
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<tr>
<td>( T_R ) = 0.234793</td>
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<td>( T_b ) = 0.010959</td>
<td>( T_b ) = 0.002850</td>
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</tr>
<tr>
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<td>( T ) = 0.196037</td>
<td>( T ) = 0.097935</td>
<td>( T ) = 0.125534</td>
</tr>
</tbody>
</table>

1. \( T_w \) refers to the Theil measure for within region inequality, \( T_b \) to between region inequality.
5 Conclusions and Remarks

This paper presents numerical simulation results on the impacts of the Hukou system of permanent registration on income inequality and labour migration in China. Our aim is to use numerical modelling to help assess the contribution of various policy and other factors in China in either contributing to or retarding inequality in China. We use three model variants to develop results. The base model is taken from Hamilton and Whalley (1984), who evaluate the impacts of cross country immigration restrictions on global inequality and examines four 2 region cases, a 3 region case, a 6 region case, and 31 province case in which alternative and groupings divisions of Chinese data are used. A second house model captures the effects of higher urban house prices in retarding rural labour movement into urban areas. A final extension allows for productivity differences across individuals within each region in the model and explores income inequality impacts for five model cases.

All model results point towards a significant role for the Hukou system in preventing movement of labour which moves the Chinese economy towards a more equal distribution of income. These effects are smaller in the second two model variants than in the first. We see all models as a simplification from a more complex reality, and so we do not aim to provide firm point estimates of impact. But the themes of results seem clear, and in addition we offer a simulation approach which can also be used for the analysis of mobility restrictions in other economies in ways different from existing econometric literature which focus on the determinants of mobility move so than impacts on overall equality and efficiency.
References


