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THE EFFECT OF CHINA HUKOU SYSTEM ON INTERNAL MIGRATION

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Abstract

Hukou system has played an important role in controlling and regulating internal migration in China, especially rural-urban migration. Since it was introduced in the 1950s, it has undergone various reforms in response to the changing situations. While the increase of migration rate since 1980s is obvious, besides hukou reforms, there are many other factors that can contribute to the increase, such as economic development or increasing urban labor demand. As a result, the increasing migration rate does not necessarily imply the restrictive effect of hukou on migration is weakening. In this paper, I estimate the change of migration friction between 2000 and 2015 to answer a central question: How much does hukou reforms improve migrants' welfare and reduce migration friction?

I begin the discussion by first providing a brief review of the history of hukou with a focus on the social and economic context of major hukou reforms. With province-level data in 2000, 2005, 2010 and 2015, I then estimate the change of migration friction over the recent years using a spatial equilibrium model. I found that migration friction across almost all provinces in 2005, 2010 and 2015 are below 2000 level. In particular, compared to urban migrants, rural migrants experienced a larger decrease in migration friction between 2000 and 2015. Further analysis indicates that recent major hukou reforms have limited impact on the change of migration friction, and many other factors, such as rising housing prices, may have contributed to the change of migration friction as well.

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Chapter 1

Introduction

1.1 Overview

Hukou system has played an important role in controlling and regulating internal migration in China, especially rural-urban migration. Since it was introduced in the 1950s, it has undergone various reforms in response to the changing situations. Along the way, the restrictive effect of the hukou system imposed on internal migration has been weakened by both hukou reforms and economic progress. The process of reform historically can be roughly divided into two phases. In the first phase (1958-1979), virtually no migration is allowed and the urban population ratio is kept below 20%, which is considerably lesser than the global average. (See Figure1.1) In the second phase (1980-present), driven by gradual reform and economic progress, the number of internal migrants has been climbing up consistently. Despite the substantial increase in migration rate over the past three decades, hukou conversion is highly restrictive in megacities where most migrants choose to work. It became common that hukou does not characterize a person’s physical location nor one’s occupation type. Since local hukou is tied to local social welfare such as access to public school and public insurance, migrants are excluded from these benefits no matter how long they stay and work in the city.[21]

The significant segregation effect of hukou gives rise to a wide range of literature investigating various impacts of hukou. Wu et al.(2014)[24] and Qian et al.(2009)[18] explore the wage-base discrimination against non-local hukou workers. Au and Henderson(2006)[4] estimate the hukou’s impact on spatial agglomeration and productivity in China. Zhang(2009)[26] demonstrates that the hukou system significantly increases the cost of unemployment for migrants. Afridi et al.(2015)[2] conduct an experiment to identify the impact of hukou on individual performance. While the topics covered in the existing literature is comprehensive, most of the studies on the impact of the hukou system are cross-sectional and offer little insight as to how the impact of the hukou system changes over time. In particular, there is little discussion on how the impact of the hukou system on migration changed over time. Bao et al.(2011)[5] is one exception. Bao et al.(2011) employed a migration choice model to determine how sensitive does the migration respond to a change in hukou policy. Bao et al.(2011) found that the migration elasticity in 1995-2000 is 23.89% lower than in 1985-90, and 9% lower than in 2000-05. This result suggests hukou has a lesser impact on individuals' migration choices in 2000-05 than in 1985-90. The impact of the hukou system on migration can also be studied by examining the welfare discount of migration in the form of migration friction. Examining the change of migration friction over time allows us to answer an important question: How much does hukou reforms improve migrants' welfare and reduce migration friction?

Many recent studies of China economy employ spatial equilibrium models to study international trade and aggregate labor productivity.[10][15][23][4][22] While many studies also incorporate a migration component in their models, most of these studies are cross-sectional and do not reveal the change of migration friction over time. Tombe and Zhu(2017)[22] is the only exception that estimates the migration friction in China for more than one period. Tombe and Zhu (2017) estimate the migration friction in 2000 and 2005 and show that there is a roughly 40% decrease in inter-provincial migration friction for rural migrants between 2000 and 2005, which is greater than my estimated 23% decrease. This discrepancy reveals an upward bias in my migration friction estimation, which I will discuss in detail in the analysis chapter.

While there are many spatial equilibrium models with a migration component, they are overly complicated for the single purpose of migration friction estimation. I use Allen and Arkolakis(2014)[3] as a base model and incorporate a migration component that is widely present in existing literature.[10][22][19][6] This allows me to estimate migration friction with a minimum data requirement. Understandably, a more complicated model could better represent the economy and produce a more accurate estimation. But as long as a model is not systematically biased or missing important components, the friction estimation in relative term will still be informative.

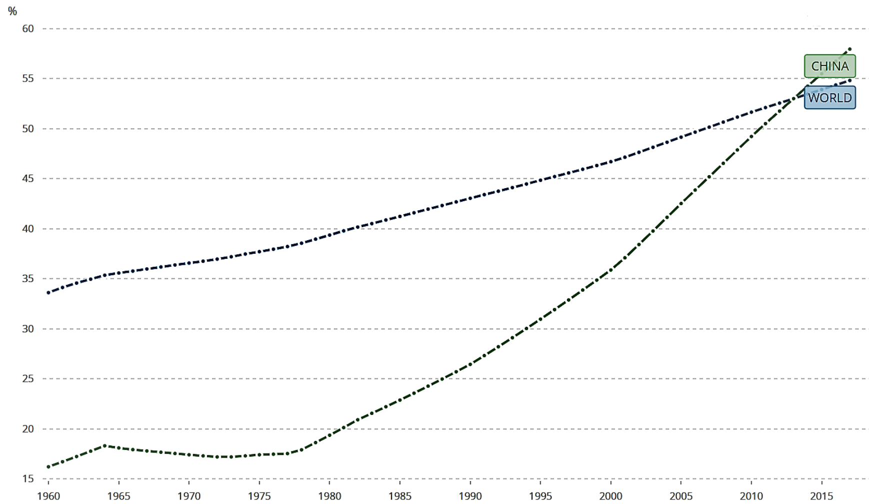
In this paper, I begin the discussion by first providing a brief review of the history of hukou with a focus on the social and economic context of major hukou reforms. With province-level data in 2000, 2005, 2010 and 2015, I then estimate the change of migration friction over the recent years using a spatial equilibrium model. I found that migration friction across almost all provinces in 2005, 2010 and 2015 are below 2000 level. In particular, compared to urban migrants, rural migrants experienced a larger decrease in migration friction between 2000 and 2015. Further analysis indicates that recent major hukou reforms have limited impact on the change of migration friction, and many other factors, such as rising housing prices, may have contributed to the change of migration friction as well.

1.2 Hukou History

This section briefly discusses the history of Hukou and the social and economic context of major Hukou reforms.

When China's Communist Party rose to power in 1949, the level of agricultural produc-

Figure 1.1: Urban Population Ratio



source United Nations Population Division. World Urbanization Prospects: 2018 Revision.

tivity was low. In an effort to ensure food provision that is essential for industrialization, the government repeatedly introduced measures to control rural-to-urban migration.[16][7] The urban-rural segregation culminated when the Hukou system was implemented nationwide in 1958. The Hukou system assigned each national a resident status of either an urban region or a rural region. Under the original Hukou system, working outside of ones' region is highly restrictive. As a result, for the first twenty years since the Hukou system was implemented, there was virtually no rural-to-urban migration.[16]

After the economic reform in 1978, rural productivity was dramatically increased and, by mid-1980s, rural underemployment became a serious problem. Around the same time, China's export-oriented growth strategy encouraged the development of township village enterprises and urban private sectors, and thus increased the demand for migrant labor.[16] The interplay between rural labor surplus and urban labor shortage posed a tremendous pressure on the Hukou system. The government first responded by allowing a small number of rural migrants to work on temporary contract in cities, then gradually expanded the practice and started devolving the hukou administrative power to lower-level governments in the early 1980s. By mid-1990s, local governments have largely obtained the hukou management power in their administrative jurisdictions, including the power to decide their local hukou admission criteria and their quota of hukou conversion. While hukou conversion remained to be difficult in many urban areas, work restrictions on non-local hukou labors were greatly relaxed.[21]

Increased urban labor demand and more tolerated work policies stimulated rural-to-urban migration. By mid-1990s, rural-hukou migrants have become the backbone in the manufacturing sector. In export-oriented industrial cities like Dongguang, migrant labor makes up more than 70% of the labor force in manufacturing in 2008. Even in a more typical inland city Wuhan, migrant labor makes up more than 40% of the labor force in manufacturing in 2000.[7]

While rural-to-urban migration since the 1980s has greatly increased the number of rural migrants in cities, a substantial amount of migrants still retain their original agricultural hukou in their original hukou location due to hukou conversion restriction. It became common that hukou does not characterize a person’s physical location nor one’s occupation type.[21] Earlier researches have shown that the tension between local resident and migrant have induced Hukou-based job discrimination, especially against rural-hukou labors in the form of wage and hiring opportunities.[17][13][1] Starting from the 2000s, in an effort to close up the segregation between agricultural hukou and nonagricultural hukou, many local governments begin to assign a unified resident hukou instead. Up till 2014, these hukou unifying reforms are largely implemented in eastern coastal provinces with limited impact on the majority of rural migrants, who are coming from western inland provinces.[21][8] Recently in 2014, the central government announced series of reforms to establish a nationwide unified hukou system for both urban and rural areas, which will eliminate the dual urban/rural nature of hukou system and promise more equitable access to public services for all nationals.

Chapter 2

Model

This section describes the spatial equilibrium model used in estimation. I use Allen and Arkolakis(2014)[3] as a base model and incorporate a migration component that is widely present in existing literature.[10][22][19][6]

2.1 Setup:

The world consists of 2N regions $g \in G$, which represents rural and urban regions of N Chinese provinces. Each region produces a unique differentiated variety of a good. The iceberg trade cost from region g to region d is given by T_{gd}. The inherent productivity and amenity of region g are denoted as $\bar{A}_d$ and $\bar{u}_d$. The productivity and amenity of region d are given by:

$$A_d = \bar{A}_d (E_d L_d)^{\alpha} \tag{2.1}$$

$$u_d = \bar{u}_d L_d^{\beta} \tag{2.2}$$

where $\alpha \geq 0$ and $\beta \leq 0$ are parameters governing the strength of productivity and amenity spillovers. L_d denotes the measure of worker working in region d and E_d denotes the average productivity of labor in d.

2.2 Worker:

Each region o is initially inhabited by a measure of l_o workers. Each worker initially in region o is allowed to move to any other region d, subjected to a migration cost given by D_{od}, where $D : G * G \to (0, 1]$ and $D_{oo} = 1$. The base utility of a region is derived from the per capita consumption of differentiated varieties and the local amenity. Workers' utility is calculated by taking the base utility and discount it by their respective migration costs. The welfare of workers i from o migrated to d is expressed as:

$$V_{od} = \frac{u_d w_d z_d(i)}{P_d D_{od}}$$

where P_d is the local price index, u_d is the local amenity, w_d is the local wage rate and $z_d(i)$ is the worker's productivity in region d.

Worker i choose a destination to maximize his welfare.

$$C(i) = \arg\max_{g \in G} \left(\frac{u_d w_d z_d(i)}{P_d D_{od}} \right)$$

To account for the idiosyncrasy of individual workers, I follow the setup in Fan(2015)[10] and assume each worker's productivity $\mathbf{z} = (z_1, z_2, ..., z_{2N})$ is a vector generated from Frechet distribution. This setup also allows each worker's draws to be correlated across regions. Formally, the vector of productivity for each worker is generated from the following CDF:

$$F(\mathbf{z}) = \exp(-(\sum_{d \in G} z_d(i)^{-\epsilon})^{1-\rho})$$

where ρ and ϵ are parameters governing the inter-regional correlation and dispersion of the workers' productivity draws.

Under this framework, the probability that a worker from region o migrates to region d is:

$$\pi_{od} = \frac{(\frac{u_d w_d}{P_d D_{od}})^{\epsilon}}{\sum_{g \in G}(\frac{u_g w_g}{P_g D_{og}})^{\epsilon}} \tag{2.3}$$

Since workers' productivity is drawn from a distribution, the average labor productivity could differ across regions. Using properties of Frechet distribution, Fan(2015)[10] shows that the average labor productivity of workers from o to d is:

$$\mathbf{E}(z_d|l_{od}) = (\frac{1}{\pi_{od}})^{\frac{1}{\epsilon}}\Gamma(1 - \frac{1}{\epsilon(1-\rho)}) \tag{2.4}$$

Where l_{od} is the measure of worker from o to d.

Therefore the average labor productivity in region d is:

$$E_d = \sum_{o \in G} \mathbf{E}(z_d|l_{od}) l_o \pi_{od} \tag{2.5}$$

2.3 Trade

Under the CES and perfect competition assumptions, the final price of good produced in region g and sold in region d is equal to the marginal production multiplied by shipping cost, $\frac{w_g}{A_g}T_{gd}$[3] Then the bilateral trade flows X_{gd} from region g to region d can be expressed as:

$$X_{gd} = (\frac{T_{gd} w_g}{A_g P_d})^{1-\sigma} w_d E_d L_d \tag{2.6}$$

where P(j) is the CES price index:

$$P_d^{1-\sigma} = \sum_{g \in G} (T_{gd})^{1-\sigma} (A_g)^{\sigma-1} (w_g)^{1-\sigma} \tag{2.7}$$

2.4 Equilibrium

Labor markets are said to be clear if the current labor in one region equal to the sum of labor migrating from all locations. i.e. for all $d \in G$

$$L_d = \sum_{o \in G} l_o \pi_{od} \tag{2.8}$$

Good markets are said to be clear if the income equal to the value of goods sold in all locations. i.e. for all $g \in G$

$$w_g E_g L_g = \sum_{d \in G} X_{gd} \tag{2.9}$$

Given parameters $\sigma, \alpha, \beta, \epsilon$ and ρ, a spatial equilibrium is defined as a distribution of economic activity s.t. (i) labor markets are clear, and (ii) good markets are clear.

Chapter 3

Estimation

3.1 Data Source

Calibrating the model mainly requires the following information: to calibrate the trade cost requires bilateral trade flow; to solve for migration friction requires regional wage rate, bilateral migration rate, and regional labor distribution. In order to study the change of migration since the year 2000, I obtain the wage, migration and labor data for the year 2000, 2005, 2010 and 2015.

3.1.1 Wage

Urban wage rate of each province over the past years can be found on China Statistical Yearbook, but rural wage rate is not published on any yearbooks. Alternatively, I use the wage ratio between urban and rural regions in 2005 inferred from Fan (2015)'s[10] published data to calculate the rural wage rate. Because there is no additional information on the rural wage of each region in the other three years, I assume the wage ratio between urban and rural regions stays constant over time, and obtain an estimation of rural wages by multiplying wage ratio with urban wages in each of the four years.

3.1.2 Regional Labor

I define the population at an age between 20 and 60 as the labor population. I calculate regional labor using regional age distribution and regional population count that can be found on the published tabulations on the following censuses: National Population Census in 2000 and 2010, and One-Percent National Sample Census in 2005 and 2015.

3.1.3 Bilateral Migration Flow

The floating population is generally defined to be people who are living in places other than their registered regions. While floating population can be considered as a group of migrant, for the purpose of this study, I narrow down the definition of migrant to be those who are working in places outside of their registered regions. Bilateral floating population flow and the worker ratio of floating population in each region can be found in the published tabulations of censuses. To each destination region, I assume the floating population coming from all source regions has the same worker ratio. With this assumption, I calculate the bilateral migration flow.

3.1.4 Bilateral Trade Flow

I use bilateral trade flow data to estimate the trade cost in 2000 and I obtain provincial bilateral trade flow data in 2000 from Fan (2015)'s[10] published data. The provincial trade flow data classified goods into two types: agricultural and non-agricultural. Furthermore, I assume rural regions only involved in the agriculture industry and urban regions only involved in the non-agricultural industry. With this assumption, I organize provincial bilateral trade flow data into region-to-province trade flow data. While urban regions rarely involve in agriculture, some rural regions that are close to urban regions do involve in the non-agricultural industry like manufacturing. As a result, my estimation of rural trade volume will have a downward bias.

3.2 Estimation

3.2.1 Parameter

There are five parameters need to be determined in this model: α and β govern the strength of productivity and amenity spillovers, ρ and ϵ govern the distribution of individual workers' productivity, and σ indicates the elasticity of substitution between goods from different regions.

For α and β that characterize the spillover effect, I use the parameter choices in Allen and Arkolakis(2014)[3], which are derived from the 2000 U.S. Census. For ρ and ϵ that characterize individual workers' productivity, I use the parameter choices in Fan(2015)[10], which are derived from the China National Population Census in 2000. For σ that characterize elasticity of trade, I use the parameter choice in Simonovska and Waugh(2014)[20], which is derived from international trade-flow data in 2004.

3.2.2 Trade Cost and Regional Production

I normalize $T_{oo} = 1$ and assume that trade costs for shipments from region o to d obey the following function:

$$\begin{aligned} T_{od} = \theta_1 + \theta_2 I_1(o) + \theta_3 I_2(o,d) + \theta_4 I_3(o,d) + \\ \theta_5 S_{od} + \theta_6 S_{od} I_1(o) + \theta_7 S_{od} I_2(o,d) + \\ \theta_8 (S_{od})^2 + \theta_9 S_{od}^2 I_1(o) + \theta_{10} S_{od}^2 I_2(o,d) \end{aligned} \tag{3.1}$$

where I_1 is a rural dummy, I_2 is an indicator for two provinces sharing a border, I_2 is an indicator for whether two provinces are both located in one of four larger geographic regions and S_{od} is the road distance between the provicial capital cities of these two regions.

Notice that the regional production A_d and the model bilateral trade volume X_{gd}^{model} are functions of T_{gd}. Given T_{gd}, we can substitute equations (2.7) and (2.9) into (2.6), and obtain consistent A_g by solving the following system of equations:

$$w_g E_g L_g = \sum_{d \in G} [(\frac{T_{gd} w_g}{A_g})^{1-\sigma} w_d E_d L_d (\sum_{k \in G} (T_{kd})^{1-\sigma} (A_k)^{\sigma-1} (w_k)^{1-\sigma})^{\sigma-1}] \tag{3.2}$$

where the only unknown variables are A_g. After A_g is calculated, we can obtain X_{gd}^{model} from equation (2.6). Therefore, assuming equation (3.1), we can determine A_g and X_{gd}^{model} from $\{\theta\}$.

As in Fan(2015)[10], my objective when choosing $\{\theta\}$ for equation (3.1) is to minimize the deviation of model bilateral trade volume from its data counterpart. Formally, I choose $\{\theta\}$ in equation (3.1) to minimize the following objective function:

$$\min_{\{\theta\}} \sum_{o \in G, p_j \in P} (log(X_{o,p_j}^{\text{data}}) - log(\sum_{d \in p_j} (X_{o,d}^{\text{model}}))^2 \tag{3.3}$$

in which $o \in G$ is a region, $p_j \in P$ is a province and $d \in p_j$ is a region within the province. Using this procedure, I estimate trade cost and regional production together.

Because I have only obtained the trade flow data in the year 2000, I do not have information to calibrate the trade cost in other years. In my experiment, I assume the trade cost is constant over time. The model regional productions for each year is calculated from labor data in their respective years and the trade cost estimated with data in 2000.

3.2.3 Migration Friction

For the variables that vary over time, I add a superscript $t \in M$ to indicate time period.

To obtain change of migration friction, I first calculate amenities-adjusted migration friction $K^t_{od} = D^t_{od}/u^t_d$ by solving equation (2.3). Notice that by equation (2.3), each row of migration friction matrix D^t_{od} is only defined up to a constant. Therefore, equation (2.3) can be simplified into:

$$\pi^t_{od} = (\frac{w^t_d}{P^t_d K^t_{od}})^\epsilon \tag{3.4}$$

where migration ratio π^t_{od} and local wage w^t_d are given by data, and P^t_d is derived from equation (2.7) using estimated trade cost and local production.

After I normalize $K^t_{oo}/L^t_o = 1$ for all $t \in M$ and $o \in G$, the growth rate of migration friction from period t to period r is:

$$\frac{D^r_{od}}{D^t_{od}} = \frac{K^r_{od}}{K^t_{od}} * (\frac{L^t_d}{L^r_d})^\beta * \frac{\bar{u_d}^t}{\bar{u_d}^r} \tag{3.5}$$

since the base amenities $\bar{u_d}^t$ cannot be identified in the model and cannot be verified using available data, I calculate the growth rate of migration friction assuming $\bar{u_d}^t$ does not vary across time.

Chapter 4

Analysis and Conclusion

4.1 Overview of Results

When estimating the migration friction, I need to assume the economy constructed from the input data is an equilibrium. When the real economy is not an equilibrium, this can result in a biased estimation. In particular, if there is a large group of migrants willing to migrate to a province but are unable to do so before the data is collected, then the estimated migration friction would have an upward bias. In an effort to address this bias, I compile the migration friction table along with migration growth rate in the bracket. If the migration growth rate is increasing, then it is likely that the prospective migrant count is larger than the current migrant count, and therefore the friction estimation has an upward bias. Similarly, if the migration growth rate is decreasing, the friction estimation is likely to have a downward bias.

4.1.1 Migration Friction Changes of Inter-provincial Urban Migrants

Since 2000, there have been many hukou policies executed by local governments to attract capital and talent. Kinnan et al.(2018)[12] documents major reforms took places in Beijing, Zhejiang, Shanghai, Jiangsu, and Shandong during the early 2000s. These provinces began to grant migrants local city hukou (or resident permits) on the condition that they have an apartment, have a stable job and, in the case of Shanghai, have a special skill. My estimation of migration friction is consistent with their finding. The measured migration friction in these five provinces in 2005 on average is 90% of the 2000 level, comparing to an average 94% in other provinces. The gap of measured change becomes larger in 2010 between these five provinces and other provinces, when the average of these five provinces is 72%, comparing to an average 81% in other provinces.

Since 2010, 11 large cities, including Beijing, Guangzhou, and Shenzhen have introduced point systems to offer a more transparent way for migrants to get local hukou. Most of the small- and medium-sized cities further removed many restrictions on hukou registration.[27] Nevertheless, urban migrant count across all the eastern provinces decreases sharply between 2010 and 2015. Except for Tianjin, all the other top 10 popular choices of urban migrant experience increases in migration friction and significant decreases in the migrant population.(See Table4.2) Since the hukou restrictions have been relaxing between 2010 and 2015, there must be some other factors contribute to the increase of migration friction of urban migrants that overtake the effect of hukou reforms.

One factor could be the surging housing price in eastern provinces. Between 2000 and 2010, the average growth of housing price is roughly the same across all provinces. However, between 2010 and 2017, the average housing price in tier 1 cities nearly double, while the housing price in tier 3 cities roughly remains the same.[11] Considering the average housing price of tier 1 cities in 2010 is already more than 2 times as much as the average housing price of tier 2 and tier 3 cities, the living pressure on urban migrants in tier 1 cities is greatly enlarged. Moreover, hukou qualification through housing purchase is popular amongst cities.[27] The surging housing price makes the majority of urban migrants impossible to own an apartment and, as a result, make the hukou conversion harder for migrants.

Consistent with the hypothesis, in the central region where provinces experience a slower increase rate of housing price, I find that the measured migration friction slightly decreases between 2010 and 2015, in contrast to the increase of migration friction in eastern provinces. Moreover, this hypothesis does not contradict the decrease in migration friction of rural migrants between 2010 and 2015, because the major of the rural migrants work on low-skill low-paying positions and cannot afford to purchase an urban apartment even before the housing price rise.

4.1.2 Migration Friction Changes of Rural Migrants

One major breakthrough of the hukou reform is the unification of rural and urban hukou registration. Starting from the 2000s, in an effort to close up the segregation between agricultural hukou and nonagricultural hukou, many local governments begin to assign a unified resident hukou instead. By 2010, there were 11 provinces unified the rural and urban hukou.[12] Recently in 2014, the central government announced series of reforms to establish a nationwide unified hukou system for both urban and rural areas, which will eliminate the dual urban/rural nature of hukou system and ensure more equitable access to public services for local residents. Consistent with these reforms, the 2010 average intra-provincial migration friction in those 11 provinces that have unified hukou is lower than the average of other provinces. (70% vs. 85% of the 2000 level) Moreover, between 2010 and 2015, the intra-provincial migration friction is reduced across all provinces, and the reduction is larger in the other 20 provinces that did not unify hukou before 2010.(See Table4.5)

On the other hand, this hukou reform has limited effect on inter-provincial rural migration. The 2010 average inter-provincial rural migration friction in those 11 provinces that have unified hukou is about the same as the average of other provinces. (58% vs 59%) While the migration friction reduces across all provinces between 2010 and 2015, the magnitude of the reduction is only slightly larger than the magnitude between 2005 and 2010.(See Table4.3) This result is understandable because welfare benefits are only for the local. For those intra-provincial rural migrants, hukou unification allows them to access some benefits in their local cities that are previously reserved only to the urban resident. However, for those inter-provincial rural migrants, hukou reform did not grant them local status and therefore are excluded from local welfare benefits just as before.[8]

If hukou unification reform has limited effect on inter-provincial rural migration, what might be the factors driving down the migration friction for inter-provincial rural migrants? In the early 2000s, factors that drive down migration friction could be a better transportation system and the removal of labor restrictions that protect local workers.[21][22] But it is unclear what factor could explain the decrease in friction between 2010 and 2015. A possible explanation for this decrease is an estimation bias incurred by wage assumption, which I will discuss in a later section.

Table 4.1: Inter-provincial Migration Friction (All Migrants)

Top 10 Provinces		2005	2010	2015
Guangdong	32.3%	0.80	0.67	0.64
		<1.42>	<1.52>	<1.08>
Zhejiang	14.7%	0.82	0.60	0.58
		<2.16>	<2.16>	<0.91>
Shanghai	11.5%	0.77	0.61	0.57
		<2.10>	<2.16>	<1.03>
Beijing	8.2%	0.89	0.65	0.63
		<1.80>	<2.28>	<1.18>
Jiangsu	7.6%	0.80	0.65	0.59
		<2.05>	<1.85>	<1.29>
Fujian	4.9%	0.84	0.72	0.65
		<1.99>	<1.57>	<1.06>
Tianjin	2.6%	0.88	0.67	0.53
		<2.31>	<2.11>	<1.89>
Shandong	1.9%	0.87	0.72	0.62
		<1.34>	<1.99>	<1.37>
Liaoning	1.7%	0.97	0.80	0.76
		<1.40>	<1.99>	<1.00>
Xinjiang	1.6%	0.98	0.75	0.68
		<0.87>	<2.63>	<1.06>
TOTAL AVERAGE		0.84	0.67	0.61
		<1.66>	<1.95>	<1.31>

Table 4.2: Inter-provincial Migration Friction (Urban Migrants)

Top 10 Provinces		2005	2010	2015
Guangdong	31.9%	0.87	0.77	0.86
		<1.42>	<1.63>	<0.53>
Zhejiang	14.5%	0.89	0.68	0.79
		<2.61>	<2.29>	<0.40>
Shanghai	10.1%	0.86	0.71	0.75
		<2.10>	<2.49>	<0.71>
Beijing	8.6%	0.94	0.72	0.81
		<2.14>	<2.36>	<0.82>
Jiangsu	7.4%	0.90	0.76	0.80
		<1.87>	<2.27>	<0.70>
Fujian	5.4%	0.95	0.83	0.90
		<2.11>	<1.74>	<0.46>
Tianjin	2.7%	0.96	0.77	0.71
		<2.38>	<2.32>	<1.16>
Shandong	2.3%	0.95	0.82	0.85
		<1.40>	<2.07>	<0.85>
Liaoning	1.7%	1.05	0.91	1.00
		<1.47>	<2.02>	<0.72>
Xinjiang	1.4%	1.09	0.83	0.84
		<0.89>	<3.60>	<0.74>
TOTAL AVERAGE		0.92	0.77	0.81
		<1.74>	<2.15>	<0.96>

Table 4.3: Inter-provincial Migration Friction (Rural Migrants)

Top 10 Provinces		2005	2010	2015
Guangdong	33.4%	0.75	0.60	0.45
		<1.43>	<1.32>	<2.23>
Zhejiang	15.2%	0.77	0.54	0.41
		<1.65>	<1.91>	<1.99>
Shanghai	14.5%	0.70	0.53	0.42
		<2.11>	<1.79>	<1.51>
Jiangsu	8.1%	0.72	0.56	0.41
		<2.33>	<1.34>	<2.50>
Beijing	7.3%	0.86	0.59	0.47
		<1.31>	<2.10>	<2.11>
Fujian	3.9%	0.75	0.62	0.43
		<1.79>	<1.21>	<2.89>
Tianjin	2.5%	0.83	0.60	0.37
		<2.21>	<1.74>	<3.60>
Xinjiang	2.0%	0.89	0.68	0.54
		<0.86>	<1.86>	<1.55>
Liaoning	1.7%	0.91	0.71	0.56
		<1.27>	<1.94>	<1.63>
Shandong	1.0%	0.80	0.64	0.43
		<1.14>	<1.69>	<3.91>
TOTAL AVERAGE		0.77	0.59	0.44
		<1.61>	<1.64>	<2.39>

Note Provinces are ranked according to the migrant worker count in 2010. The percentage indicates the share of the migrant count in a province in 2010. The number without bracket indicates the ratio of weighted average migration friction across all origins to the row destination between the column year and the base year 2000. The number in the bracket indicates the migration growth rate over the last five years. In the final row, the total average presents the average statistics of all 31 provinces.

Table 4.4: Migration Friction (All Migrants)

Top 10 Provinces		2005	2010	2015
Guangdong	26.9%	0.82	0.69	0.65
		<1.43>	<1.53>	<1.30>
Zhejiang	12.5%	0.84	0.62	0.59
		<1.76>	<2.06>	<1.09>
Shanghai	8.8%	0.77	0.61	0.57
		<2.06>	<2.14>	<1.07>
Jiangsu	7.1%	0.82	0.67	0.60
		<1.63>	<1.68>	<1.53>
Beijing	6.4%	0.90	0.65	0.63
		<1.70>	<2.29>	<1.23>
Fujian	4.9%	0.85	0.72	0.66
		<1.82>	<1.54>	<1.66>
Sichuan	2.5%	1.12	0.74	0.55
		<0.77>	<3.57>	<2.97>
Henan	2.4%	1.06	0.84	0.61
		<0.56>	<3.53>	<2.13>
Shandong	2.2%	0.91	0.76	0.64
		<0.93>	<1.85>	<3.59>
Tianjin	2.0%	0.89	0.68	0.53
		<1.96>	<2.11>	<1.94>
TOTAL AVERAGE		0.87	0.70	0.63
		<1.45>	<1.99>	<1.98>

Table 4.5: Intra-provincial Migration Friction (Rural Migrants)

Top 10 Provinces		2005	2010	2015
Henan	8.7%	0.98	0.66	0.47
		<0.56>	<3.80>	<1.96>
Shandong	7.5%	0.97	0.84	0.46
		<0.62>	<1.62>	<8.06>
Sichuan	7.2%	0.93	0.61	0.41
		<0.80>	<3.47>	<3.22>
Hebei	6.3%	0.89	0.66	0.45
		<0.92>	<2.12>	<3.01>
Hunan	6.0%	0.85	0.70	0.46
		<0.97>	<1.61>	<3.15>
Anhui	5.2%	0.85	0.72	0.46
		<0.75>	<1.83>	<4.20>
Hubei	4.6%	0.95	0.81	0.50
		<0.87>	<1.58>	<4.63>
Guangdong	4.6%	0.79	0.65	0.47
		<1.55>	<1.74>	<3.76>
Jiangsu	4.5%	0.79	0.68	0.48
		<1.04>	<1.19>	<2.55>
Yunnan	4.5%	0.96	0.83	0.58
		<0.66>	<1.65>	<2.59>
TOTAL AVERAGE		0.92	0.73	0.49
		<0.86>	<2.18>	<3.48>

Note Provinces are ranked according to the migrant worker count in 2010. The percentage indicates the share of the migrant count in a province in 2010. The number without bracket indicates the ratio of weighted average migration friction across all origins to the row destination between the column year and the base year 2000. The number in the bracket indicates the migration growth rate over the last five years. In the final row, the total average presents the average statistics of all 31 provinces.

4.2 Discussion of Biases in Estimation

4.2.1 Biases incurred by Trade Cost Assumption

My estimations of the migration friction in each of the four years are based on the trade cost estimated using 2000 data. In the model, each column of trade cost matrix T_{od} are defined only up to a constant. Using the 2000 trade cost to estimate migration friction in any other year can produce consistent results only if the ratio amongst $(T_{1d}, T_{2d}, ..., T_{nd})$ remains the same for all $d \in G$.

Tombe and Zhu(2017)[22] infer the trade cost in 2002 and 2007 from trade share data. They found that the trade costs between different geographic regions are decreasing at different rates. In particular, the trade costs between more developed regions, like southern and eastern coastal provinces, decrease roughly 30% faster than the trade costs between developing western and central regions.

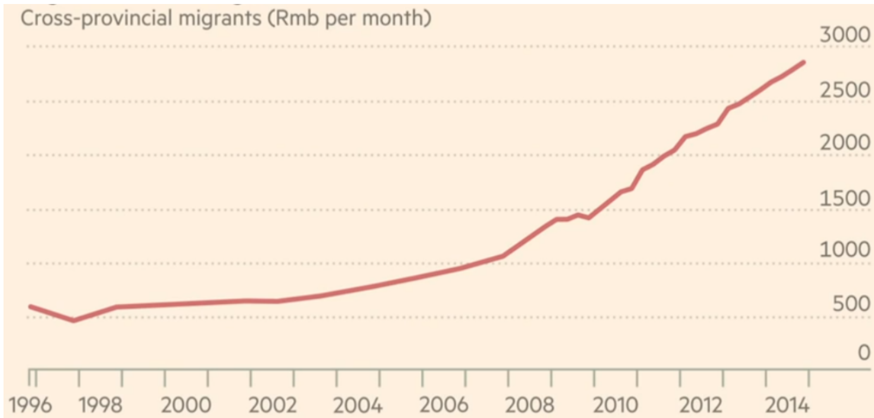
If I allow trade costs between more developed regions to decrease faster over time, then the price index in the more developed regions calculated from equation 2.7 will be less than the current value. Consequently, the estimated migration friction in these more developed regions will also be less than the current value. In conclusion, using trade cost estimated with 2000 data to calculate migration friction in different years results in an upward biased estimation of average migration friction. Moreover, the bias becomes larger as the year increases.

4.2.2 Biases incurred by Wage Assumption

When estimating migration friction change over time, I assumed the wages of all workers in a region are increasing at the same rate. However, this may not be the case. Wage discrimination against migrants is documented in many studies using wage data in the 2000s. During the 2000s, migrants not only received lower wages compared to urban workers but also experienced a slower income growth.[21][16] Meng(2012)[16] uses a monthly earnings data of migrants and urban workers for 15 cities between 2002 and 2008 and finds that income growth of urban workers on average is four-time faster than that of migrants. If this trend holds between 2000 and 2010, the estimated migration friction in 2005 and 2010 will have an upward bias.

There is an additional complexity arisen from recent rapid wage increase for low-skill migrant workers. There have been noticeable labor shortages in low-skill positions since 2010 and China media have reported labor shortages all over the country.[25] In order to attract more laborers, many factories started offering higher wages. Between 2010 and 2015, the average wage of migrant has doubled.(See Figure4.1) Dreger and Zhang (2017)[9] found that while there is wage discrimination against migrants in 2007, the discrimination effect completely dissipated in 2013. Moreover, factories even offer wage premium to partially offset the migration cost of non-local hukou holders. As a result, the wage of rural workers should increase at a rate faster than the average increase rate of the region between 2010 and 2015. The rapid wage increase over the recent year should result in a downward estimation of the migration friction of rural migrants in 2015.

Figure 4.1: Average Migrant Wage



source Lu Feng (2011)[14], National Bureau of Statistics, CEIC. Compiled by Financial Times

4.2.3 Comparing with the Estimation in Tombe and Zhu[22]

For the purpose of this paper, I estimate migration friction only in relative term. However, most studies exploring the impact of the hukou system on migration are cross-sectional, making a direct comparison impossible. Tombe and Zhu(2017) is the only study I am aware of that estimates the migration friction in China for more than one period. Tombe and Zhu(2017) estimates the migration friction in 2000 and 2005 using individual-level census data, and find that the inter-provincial migration friction of rural migrants decreases by almost 40% and intra-provincial migration friction decreases by 18%. Consistent with Tombe and Zhu(2017)'s estimation, my estimation also show a larger decrease in inter-provincial migration friction during the period.(23% vs 8%) While Tombe and Zhu(2017) records a larger reduction, the difference is still reconcilable taking into the account of the upward biases of my estimation.

On the other hand, Tombe and Zhu(2017)'s estimation of inter-provincial migration friction of urban migrants is inconsistent with mine. Tombe and Zhu(2017) find an over-40% decrease for urban migrants between 2000 and 2005 while I only find a decrease of 8%. It is hard to judge which figure is more accurate. Unlike rural-to-urban migration, which has been widely studied, urban-to-urban migration is largely overlooked. Moreover, there is no discussion on urban-to-urban migration in Tombe and Zhu(2017).

4.3 Improving the Model

International trade represents a significant share of China GDP (see Figure 4.2,4.3), but is not represented in my current model. Adding an international trade component can be significant for two reasons: Firstly, the majority of inter-provincial migrants are working in coastal provinces where international trade is a significant component of the local economy. Failure to recognize the influence of international trade essentially renders the equilibrium model incomplete. Secondly, international trade is volatile and has been fluctuating remarkably between 2000 and 2015. Consequently, ignoring international trade

Figure 4.2: Import-to-GDP Ratio

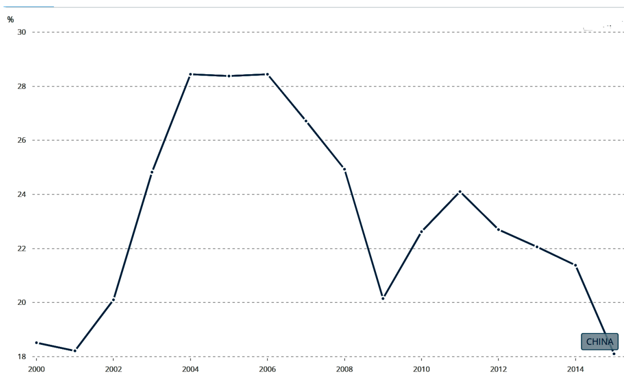
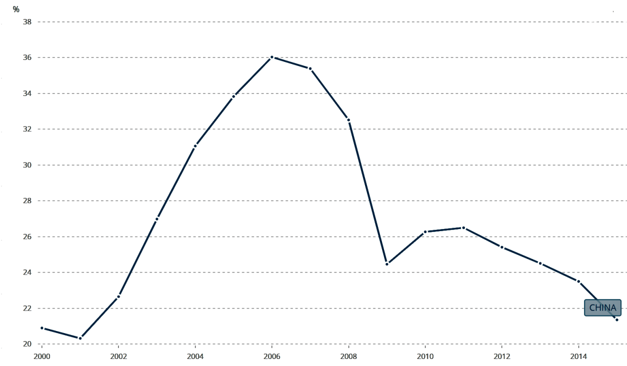


Figure 4.3: Export-to-GDP Ratio



source World Bank national accounts data, and OECD National Accounts data files

component could lead to a systematic bias in the model estimation.

An international component can be added to my current model by adding an additional region with the same properties as any other regions except a restriction that no migration is allowed.

4.4 Conclusion

This paper estimates the change of migration friction over recent years using a spatial equilibrium model. I found that migration friction across almost all provinces in 2005, 2010 and 2015 are below 2000 level. In particular, compared to urban migrants, rural migrants experienced a larger decrease in migration friction between 2000 and 2015. I then reviewed some major hukou reforms since 2000 and discussed the possible connections between hukou reforms and changes of migration friction. In particular, I found that the recent unification of rural-urban hukou considerably decreased the migration friction of intra-provincial rural migrants, but has little impact on inter-provincial rural migrants.

In general, while the major reforms I reviewed decrease the migration friction, these reductions coming from reforms are not enough to explain the changes in migration friction. I then proposed other factors that could have contributed to the change of migration friction and supported these hypotheses with evidence coming from my estimation as well as other studies.

Chapter 5

Transport Cost Estimation Code

```
clear
addpath(genpath(pwd));
InputData=READ_DATA;
Params=DEFINE_PARAMS;
Efficiency=EFFICIENCY(InputData,Params);

myCluster = parcluster('local');
myCluster.NumWorkers = 4;
saveProfile(myCluster);
options = optimset('Display','on','PlotFcns',@optimplotfval,'TolFun',10^(-6),'TolX',10^↙
(-6),'MaxFunEvals',10^10,'MaxIter',10^10,'FunValCheck','on');
theta=[[1,1,1,1,1,1,1,1,1]'];

count=1;
save('../temp/count.mat','count');
[theta,fval,exitflag,output] = fminsearch(@(theta) Parametrize_T(theta,InputData, ↙
Efficiency,Params),theta,options);
TC=T_Model_Estimation(InputData,theta);

load('../temp/A.mat','A');
A0=A;
save('../output/transport_cost_new/A_temp.mat' ,'A0');

%% Dependent Functions
function [obj]=Parametrize_T(allparam,InputData,Efficiency,Params,count)
load('../temp/count.mat','count');
TC=T_Model_Estimation(InputData,allparam);
obj=ObjectiveFunction(TC,InputData,Efficiency,Params,count);
count=count+1
save('../temp/count.mat','count');
end

function TC=T_Model_Estimation(InputData,theta)
thata=theta
TC_temp=zeros(62,62);
for o=1:62
    for d=1:62
        TC_temp(o,d)=theta(1)+theta(2)*mod(o+1,2)+theta(3)*InputData.Same_Region_Dummy ↙
(o,d)+ ...
                    theta(4)*InputData.Prov_dist(o,d)+ ...
                    theta(5)*InputData.Prov_dist(o,d)*mod(o+1,2)+ ...
                    theta(6)*InputData.Prov_dist(o,d)*InputData.Same_Region_Dummy(o,d)+ ↙
...
                    theta(7)*InputData.Prov_dist(o,d)^2+ ...
                    theta(8)*InputData.Prov_dist(o,d)^2*mod(o+1,2)+ ...
                    theta(9)*InputData.Prov_dist(o,d)^2*InputData.Same_Region_Dummy(o, ↙
d)+ ...
                    theta(10)*InputData.Border_Dummy(o,d);
    end
end
```

```
for o=1:31
    TC_temp(2*o,2*o-1)=theta(1)+theta(2);
    TC_temp(2*o-1,2*o)=theta(1);
end

for o=1:62
    TC_temp(o,o)=1;
end

for o=1:62
    for d=1:62
        if TC_temp(o,d)<1
            TC_temp(o,d)=1;
        end
    end
end

TC=TC_temp;
save('../output/transport_cost_new/theta2000.mat','theta');
save('../output/transport_cost_new/TC2000.mat','TC');
end

function obj=ObjectiveFunction(TC,InputData,Efficiency,Params,count)
TCs=TC.^(1-Params.sigma);
temp1=zeros(62,1);
temp2=zeros(62,1);
temp3=zeros(62,62);
temp4=zeros(62,1);
eX=zeros(62,62);

Wage=InputData.Wage2000;
Efficiency=Efficiency.E2000;
Labor=InputData.Labor2000;
A=InputData.GDP2000;
X=InputData.Trade_Flow_2000;

A=A_Matrix_2000(InputData,Efficiency,Params,TC,count);

temp1=Wage.*Efficiency.*Labor;
temp2=(A./Wage).^(Params.sigma-1);
for o=1:62
    for d=1:62
        temp3(o,d)=temp2(o)*temp1(d);
    end
end
for d=1:62
    temp4(d)=sum(TCs(:,d).*temp2);
end
for g=1:62
```

```
    for d=1:62
        eX(g,d)=TCs(g,d).*temp2(g).*temp1(d)./temp4(d);
    end
end

obj=Compare_With_Data(X,eX);
end

function obj=Compare_With_Data(X,eX)
    eX2=zeros(62,31);
    for d=1:31
        eX2(:,d)=eX(:,2*d)+eX(:,2*d-1);
    end
    X=X./mean(mean(X))+0.16;
    eX2=eX2./mean(mean(eX2))+0.16;
    Xdiffsq=(log(X)-log(eX2)).^2;
    X=X-0.16;
    eX2=eX2-0.16;

    Xdiffsq(51:52,:)=[];
    Xdiffsq(:,26)=[];

    save('../temp/obj2000_transport_cost.mat','Xdiffsq','eX2','X');
    obj=sum(sum(Xdiffsq));
end

function A=A_Matrix_2000(InputData,Efficiency,Params,TC,count)
options_fmincon = optimoptions('fmincon','UseParallel',true,'Algorithm','interior-↙
point','Display','off','TolFun',10^(-6),'TolX',10^(-6),'MaxFunEvals',10^5,'MaxIter',↙
10^5,'FunValCheck','on');
options_pattern = optimoptions('patternsearch','UseParallel',↙
true,'Display','off','TolFun',10^(-8),'TolX',10^(-8),'MaxFunEvals',5*10^5,'MaxIter',↙
10^8,'PlotFcn',@psplotbestf);

load('../temp/A.mat','A');
store=M2STORE_FOR_CAL(InputData,Efficiency,Params,TC);
if mod(count,1000)==0
    [A,fval,exitflag,output]=patternsearch(@(xa) M2T_constrain(xa,store,Params), ↙
InputData.GDP2000,[],[],[],[],zeros(62,1),ones(62,1),[],options_pattern);
    fval=fval
    output=output
end
[A,fval,exitflag,output]=fmincon(@(xa) M2T_constrain(xa,store,Params),A,[],[],[],[], ↙
zeros(62,1),ones(62,1),[],options_fmincon);
save('../temp/A.mat','A');
fval=fval
output=output
A=A./mean(A);
end
```

```
function store=M2STORE_FOR_CAL(InputData,Efficiency,Params,TC)
Wage=InputData.Wage2000;
Labor=InputData.Labor2000;
A=InputData.GDP2000;
X=InputData.Trade_Flow_2000;
S1=zeros(62,62);
S2=zeros(62,62);
S3=zeros(62,1);

for g=1:62
    for d=1:62
        S1(g,d)=(TC(g,d)*Wage(g))^(1-Params.sigma)*Wage(d)*Efficiency(d)*Labor(d);
        S2(g,d)=(TC(g,d)*Wage(g))^(1-Params.sigma);
    end
    S3(g)=Wage(g)*Efficiency(g)*Labor(g);
end

store=v2struct(S1, S2, S3);

end

function y=M2T_constrain(a,store,Params)
A=a;
A=A./mean(A);

S1=store.S1;
S2=store.S2;
S3=store.S3;

S4=zeros(62,1);
S5=zeros(62,1);

for d=1:62
    for g=1:62
        S4(d)=S4(d)+S2(g,d)*a(d)^(Params.sigma-1);
    end
end

for g=1:62
    for d=1:62
        S5(d)=S5(d)+S1(g,d)*a(g)^(Params.sigma-1)/S4(d);
    end
end
y=sum((S3-S5).^2);
end
```

```
clear
addpath(genpath(pwd));
InputData=READ_DATA;
Params=DEFINE_PARAMS;
Efficiency=EFFICIENCY(InputData,Params);

options_fmincon = optimoptions('fmincon','UseParallel',false,'Display','off','TolFun',↙
10^(-10),'TolX',10^(-10),'MaxFunEvals',10^6,'MaxIter',10^8);

myCluster = parcluster('local');
myCluster.NumWorkers = 4;
saveProfile(myCluster);
parpool(4);

load('../output/transport_cost_new/A_temp.mat','A0');
spmd
if labindex ==1
A_Matrix_2000(InputData,Efficiency,Params,options_fmincon,A0);

elseif labindex==2
A_Matrix_2005(InputData,Efficiency,Params,options_fmincon,A0);

elseif labindex==3
A_Matrix_2010(InputData,Efficiency,Params,options_fmincon,A0);

elseif labindex==4
A_Matrix_2015(InputData,Efficiency,Params,options_fmincon,A0);
end
end

%% Dependent Function
function A_Matrix_2000(InputData,Efficiency,Params,options_fmincon,A0)
load('../output/transport_cost_new/A_matrix_2000.mat','A');
store=M2STORE_FOR_CAL(InputData,Efficiency,Params,2000);
[A,fval,exitflag,output]=fmincon(@(xa) M2T_constrain(xa,store,Params,2000,0),A0,[],[], ↙
[],[],zeros(62,1),ones(62,1),[],options_fmincon);
fval=fval
output=output
A=A./mean(A);
save('../output/transport_cost_new/A_matrix_2000.mat','A');
end

function A_Matrix_2005(InputData,Efficiency,Params,options_fmincon,A0)
load('../output/transport_cost_new/A_matrix_2005.mat','A');
store=M2STORE_FOR_CAL(InputData,Efficiency,Params,2005);
[A,fval,exitflag,output]=fmincon(@(xa) M2T_constrain(xa,store,Params,2005,0),A0,[],[], ↙
[],[],zeros(62,1),ones(62,1),[],options_fmincon);
fval=fval
output=output
A=A./mean(A);
```

```
save('../output/transport_cost_new/A_matrix_2005.mat','A');
end

function A_Matrix_2010(InputData,Efficiency,Params,options_fmincon,A0)
load('../output/transport_cost_new/A_matrix_2010.mat','A');
store=M2STORE_FOR_CAL(InputData,Efficiency,Params,2010);
[A,fval,exitflag,output]=fmincon(@(xa) M2T_constrain(xa,store,Params,2010,0),A0,[],[], ↙
[],[],zeros(62,1),ones(62,1),[],options_fmincon);
fval=fval
output=output
A=A./mean(A);
save('../output/transport_cost_new/A_matrix_2010.mat','A');
end

function A_Matrix_2015(InputData,Efficiency,Params,options_fmincon,A0)
load('../output/transport_cost_new/A_matrix_2015.mat','A');
store=M2STORE_FOR_CAL(InputData,Efficiency,Params,2015);
[A,fval,exitflag,output]=fmincon(@(xa) M2T_constrain(xa,store,Params,2015,0),A0,[],[], ↙
[],[],zeros(62,1),ones(62,1),[],options_fmincon);
fval=fval
output=output
A=A./mean(A);
save('../output/transport_cost_new/A_matrix_2015.mat','A');
end

function store=M2STORE_FOR_CAL(InputData,Efficiency,Params,year)
load('../output/transport_cost_new/TC2000.mat','TC');

if year==2000
    Wage=InputData.Wage2000;
    Efficiency=Efficiency.E2000;
    Labor=InputData.Labor2000;
end
if year==2005
    Wage=InputData.Wage2005;
    Efficiency=Efficiency.E2005;
    Labor=InputData.Labor2005;
end
if year==2010
    Wage=InputData.Wage2010;
    Efficiency=Efficiency.E2010;
    Labor=InputData.Labor2010;
end
if year==2015
    Wage=InputData.Wage2015;
    Efficiency=Efficiency.E2015;
    Labor=InputData.Labor2015;
end
S1=zeros(62,62);
S2=zeros(62,62);
```

```
S3=zeros(62,1);

for g=1:62
    for d=1:62
        S1(g,d)=(TC(g,d)*Wage(g))^(1-Params.sigma)*Wage(d)*Efficiency(d)*Labor(d);
        S2(g,d)=(TC(g,d)*Wage(g))^(1-Params.sigma);
    end
    S3(g)=Wage(g)*Efficiency(g)*Labor(g);
end

store=v2struct(S1, S2, S3);
end

function y=M2T_constrain(a,store,Params,year,isnumber)
A=a;
A=A./mean(A);

if year==2000
save('../output/transport_cost_new/A_matrix_2000.mat','A');
end
if year==2005
save('../output/transport_cost_new/A_matrix_2005.mat','A');
end
if year==2010
save('../output/transport_cost_new/A_matrix_2010.mat','A');
end
if year==2015
save('../output/transport_cost_new/A_matrix_2015.mat','A');
end

S1=store.S1;
S2=store.S2;
S3=store.S3;

S4=zeros(62,1);
S5=zeros(62,1);

for d=1:62
    for g=1:62
        S4(d)=S4(d)+S2(g,d)*a(d)^(Params.sigma-1);
    end
end

for g=1:62
    for d=1:62
        S5(d)=S5(d)+S1(g,d)*a(g)^(Params.sigma-1)/S4(d);
    end
end

if isnumber==0
```

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Master of Art in Economics (From Aug 2018-May 2019)
Thesis: The Effect of China Hukou System on Internal Migration

The Pennsylvania State University University Park, PA
Department of Mathematics
Mathematics Advanced Study Semesters (From Aug 2017-Dec 2017)
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Experience

The Pennsylvania State University University Park, PA
Research Assistant (May 2018 – May 2019)

- Devise algorithms to analyze datasets using Stata and Python
- Visualize and extract geographic information using ArcGIS and Python

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- Grade and create solutions for upper-class courses in Classical Analysis and Numerical Analysis

Activities and Honors

Bates White Research Program (Sep 2018-Dec 2018)
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