Migration and Structural Transformation in China

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Abstract

Since China's 1978 economic reform, its agricultural employment share decreased from 69% to 17% in 2015 over 37 years. In contrast, this level of reduction in agricultural employment share took the US 104 years to achieve. This paper uncovers that China's rapid sectoral labor reallocation was helped by mass migration from Western to Eastern regions. In the late 1990s, the former small-scale migration within each region was replaced by mass West to East migration. This mass cross-region and cross-sector migration is the major contributing factor for the Eastern region's rapid non-agricultural employment growth, making the region an engine of structural transformation. The 2010s saw an increase in out-of-agriculture reallocation in the West, accelerating the Western region's nonagricultural sectoral growth.

To understand how migration contributes to structural transformation and economic growth, I build a two-sector two-region model and study how migration mitigates labor market distortion both between sectors and across regions over the period 1978-2015. Although the sectoral and regional migration barriers have declined over time, the potential output and welfare gain from removing the remaining migration barriers are still high.

Keywords: Labor reallocation, migration, structural transformation
JEL classifications: J62, J61, E24

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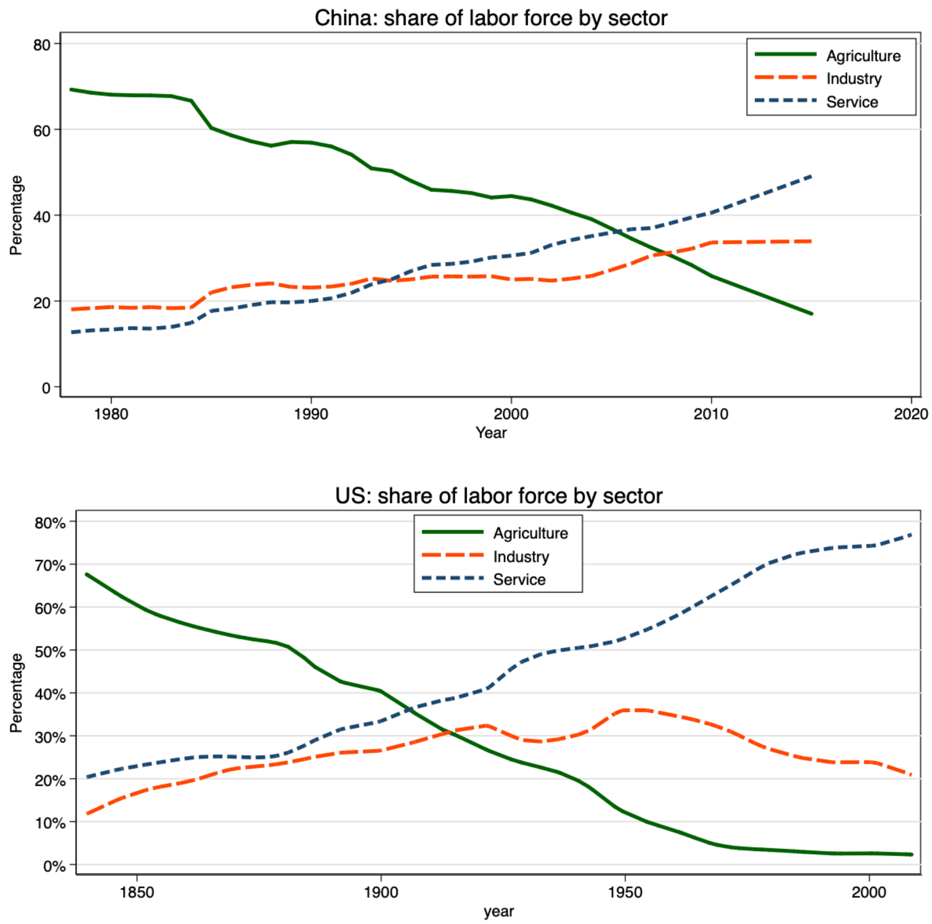
1 Introduction

China experienced unprecedented economic growth since the economic reform in 1978. Its extraordinary economic growth was partly driven by mass reallocation of labor. In 2010, a stock of 108 million migrant workers resided and worked out of their home county, while 16 million workers moved in that single year. The mass cross-region migration contributed greatly to China's economic growth and structural transformation. To understand how migration contributes to structural transformation and economic growth, I quantify the impact of migration barriers between both sectors and regions and study welfare and output gain from removing these barriers.

Structural transformation occurred much faster in China compared to most developed nations. Structural transformation, which refers to the reallocation of economic activity across the main sectors of the economy, is a common experience for all countries as they develop (Kongsamut et al., 2001; Ngai and Pissarides, 2007; Herrendorf et al., 2014). Many studies focus on the slow reallocation of labor out of agriculture in developed nations and how it lowers economic growth (Freeman and Katz, 1995; Hayashi and Prescott, 2008; Schoellman and Hobijn, 2017). In the case of China, a special hukou registration system was designed in the 1950s to control labor mobility between locations and sectors. Despite the policy constraint, China's agricultural employment decreased from 69% in 1978 to 17% in 2015, indicating that half of the labor force shifted into the nonagricultural sectors within only 37 years. The same change took the US 104 years as figure 1 suggested.

During China's rapid structural transformation, I find distinctive migration patterns in the Eastern and Western region and carefully document regional migration trends and employment changes. Before 1990, only a small group of migrants reallocated from agriculture to nonagriculture but remained within each region. 1990 to 2005 mostly saw mass migration from the Western agricultural sector to the Eastern nonagricultural sector, contributing to structural transformation in both regions by reducing agricultural employment in the Western region and increasing nonagri-

Figure 1: Sectoral Employment Share - China and the US



Note: Upper graph by author. Lower graph from Johnston (2012).

cultural employment in the Eastern region. After 2005, while regional migration declined, the Western region saw an increasing group of people moving from agriculture to nonagriculture.

A structural model is needed to understand the economic contribution of the observed cross-region and sector migration. Based on these facts, I build a 2-region 2-sector model to study how labor reallocation affects output and welfare in China. My theory combines a classic structural transformation model with a migration model of frictional labor mobility. Like most structural transformation papers, there is less need for labor in agriculture when agricultural productivity increases. At the same time, farmers in the less developed Western region have the option to migrate to the higher income nonagricultural sector in the Eastern region.

Another contribution of this paper is that I construct a sectoral employment, output and price data at the provincial level that spans from 1978 to 2015. Using multiple statistical sources, I compute more accurate provincial and sectoral level employment data. I back out the price deflator separately for each province from the statistical yearbooks and official data books. This data allows me to study long-run economic growth at the regional level.

The model and dataset allow me to quantify migration costs between sectors and regions and track any changes over time. I find large but declining migration costs within both regions. The migration cost between the Eastern and Western regions also declines. I run a variety of counterfactual experiments, simulating output and welfare by either restoring migration or eliminating migration barriers one at a time and comparing the various outcomes. When all the migrants are restored to their home region and sector, the overall output would be 34% lower in 2015. Despite large gain from migration, the counterfactuals also suggest large potential gain from further labor reallocation. Potential output gain is high after 1990 because reducing one unit of migration barrier can lead to more output in the later years. As for 2015, completely eliminating the migration barrier can increase output and welfare by as high as 21%.

My work contribute to the regional development literature which includes both empirical papers (Kanbur and Zhang, 1999) and theoretical papers (Caselli and Coleman II, 2001). This paper also build on an emerging literature that studies factor allocation across regions and production sectors (Hsieh and Klenow, 2009; Brandt et al., 2013) with many paper focus on labor (Eckert et al., 2018; Bryan and Morten, 2019; Tombe and Zhu, 2019; Hao et al., 2019).

The remainder of the paper is structured as follows. Section 2 first describes migration policy and data construction and then shows how migration, especially cross-sector and cross-region migration, contribute to the nonagricultural sector's employment growth. Section 3 constructs a macro model to study labor market distortion. The same section examines the potential gain from removing cross-sector and cross-region migration barriers. Finally, Section 4 concludes.

2 China's Growth and Migration

The Chinese structural transformation and migration in the past four decades were compelling. In this section, I first document migration-related institutional changes. Then I discuss employment and migration data in detail. In the end, I study the role of migration in the process of structural transformation.

2.1 Migration policy

The Chinese government designed the hukou registration system for labor control in the planned economy era. Chan (2019) carefully documented the migration policies and the observed migration growth. During the Big Push industrialization in the late 1950s, nationalized urban industries were the priority of the country and resources were extracted from rural to urban for capital accumulation in industry. Each individual is assigned either "agricultural (Agri)" or "nonagricultural (NonAgri)" hukou (registration) in a specific location. Basic welfare such as education and health care were provided to NonAgri hukou workers who work in the cities, which was 15% of the population. The non-priority agricultural sector provided cheap raw material to the industrial sector. Farmers were left with subsistence consumption and receive very little welfare compared to the workers in cities. In the 1950s when the system first set up, changing hukou category and location were tightly controlled by the local government and migration without hukou conversion is now allowed. Hukou registration system created two societies by restricting labor mobility.

In the mid-1980, as a response to the labor demand in the labor-intensive industries, migrant workers emerge as temporary residences in the cities. But the state is not fiscally responsible for their welfare. As labor demand grows over time, migrant workers become the major labor in the export-oriented manufacturing sector in the 1990s and 2000s, especially in the coastal provinces. Although migrant workers contribute to the destination economy, they are not accessible to city-related welfare and benefit without a hukou in the destination.

Social welfare and benefit are tied to a local hukou, and changing hukou to the preferred location is hard for most of the migrants. Following the end of food rationing in 1992, the local government has more power on hukou conversion and can set their entry conditions. However, the entry conditions are usually high and limited to investors or people with special skills. Some neighboring rural towns are given NonAgri hukou, but these are not the ideal destination for migrants. In the late 1990s, a few places start to eliminate the difference between Agri and NonAgri hukou. This is eventually extended to the whole nation in 2014. However, conversion to NonAgri hukou gives migrants no significant change to social benefits. The distinction of welfare and benefit entitlement is more about having local hukou (Chan, 2019).

2.2 Data and Stylized Facts

To generate measures for the regional factor allocation from 1978 to 2015, output, employment, and migration data at provincial- and sectoral-level are required. Each series is constructed by agricultural and nonagricultural sectors and by Eastern and Western region[1]. The main source of data is the Chinese Statistical Yearbook published by China's National Bureau of Statistics (NBS).

2.2.1 GDP and GDP deflator

The annual Yearbooks report nominal GDP and real GDP growth for each province and by primary, secondary and tertiary sectors. Nominal GDP and real GDP growth are from the Yearbooks and supplemented by statistical data books. The Yearbooks cover provincial and three-sector nominal GDP and real GDP growth rate from 1978 to 2015. To incorporate the two major revisions following the 1993 Tertiary Sector Census and 2004 Economic Census[2], the revised 1978-93, 1993-2004 provincial and sectoral data from *GDP 1952-95* and *GDP 1952-2004* are employed following the suggestion of Holz (2006). Provincial-sectoral GDP is then proportionally rescaled such that the sum across provinces equals the national total in every year reported in the 2016 Yearbook.

GDP deflator can be calculated from nominal GDP, real GDP growth rate and price level difference in 1990. The growth rate of GDP deflator is given by the ratio of nominal to real GDP growth rate for each province and sector. However, this deflator only shows price differences across time but remain incomparable across provinces and sectors. Brandt and Holz (2006) construct the cost of the spatial and urban-rural baskets. To compare price level differences across provinces and sectors in our base year 1990, the 1990 GDP deflator is set equal to each provinces'

[1] The Eastern region: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan Province.
The Western region: Shanxi, InnerMongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang Province.

[2] The 1993 Tertiary Sector Census and 2004 Economic Census revise up both nominal and real output in the tertiary sector (Holz, 2006).

cost of a common basket of goods relative to the national average. In the base year, I use the common basket price index for rural areas to deflate agriculture's nominal GDP in each province and use the common price index for urban areas to deflate nonagriculture's nominal GDP.

One potential issue with using the rural and urban price index as the agriculture and nonagricultural price in the base year is that I would not accurately measure the real nonagricultural output in the rural area. This is because, while the agricultural good is produced solely by rural workers, the nonagricultural good is produced in both rural[3] and urban areas. Assigning the urban price index to nonagriculture in the base year assumes this urban price is faced by all nonagriculture producers. This is inaccurate because the portion of nonagricultural goods produced in rural area should be deflated with rural prices, which are lower than urban prices. Therefore, employing the urban price index to calculate the real nonagricultural output would underestimate the overall real nonagricultural output.

2.2.2 Employment Data

The Yearbooks provide employment data at the province level by primary, secondary and tertiary sectors. There are two difficulties with the official employment data. First, there is a major discontinuity in reported national employment levels in 1990. This is because, after the 1990 Census, the NBS adjusted up post-1990 national employment, but did not make adjustments for pre-1990 national employment. Following Holz (2006) and Brandt and Zhu (2010), I make the necessary upward adjustment to pre-1990 national employment levels using the 1982 Census, which gives the same national employment levels as these reference papers. Additionally, NBS slightly revised down national employment levels for 2001-2010 following the 2010 Census. As a result, 2001-2010 provincial employment is deflated such that provincial summation equals to the revised national level reported in 2016 Yearbook.

[3]Rural nonagricultural good is produced by rural Township and Village Enterprises (TVE), rural private firm and rural self-employed workers

Secondly, the NBS underestimates the rate of decline in primary sector employment (Rawski and Mead, 1998) possibly by including workers involving in part-time farming activities (Holz, 2006). An alternative estimate of agricultural employment is constructed from the Rural-Urban employment table:

$$\begin{aligned} \text{Agricultural Employment} = &\ \text{Rural Employment} \\ &- \text{Township and Village Enterprises Employment} \\ &- \text{Rural Private Employment} \\ &- \text{Rural Self-Employed.} \end{aligned}$$

The residual employment is nonagricultural. My Yearbook estimate suggests 316.61 million agricultural employment in 1996 and the 1996 Agriculture Census reports 311.5 million full-time farmers, which is very close. My Yearbook estimate should be a good measure for full-time farmers. At the provincial level, the employment data from Yearbooks is supplemented with 1978-1992 employment data from the *17-years Regional Economy* data book. Provincial agricultural and nonagricultural employment is calculated the same way but only up to 2010 because the NBS stops reporting provincial rural-urban employment afterward in almost all published resources. As a result, the 2015 provincial employment can only be temporarily estimated from each provincial yearbook[4]. Provincial sectoral employments are then re-scaled proportionately such that the sum across the provinces of each sector equals national sectoral employment.

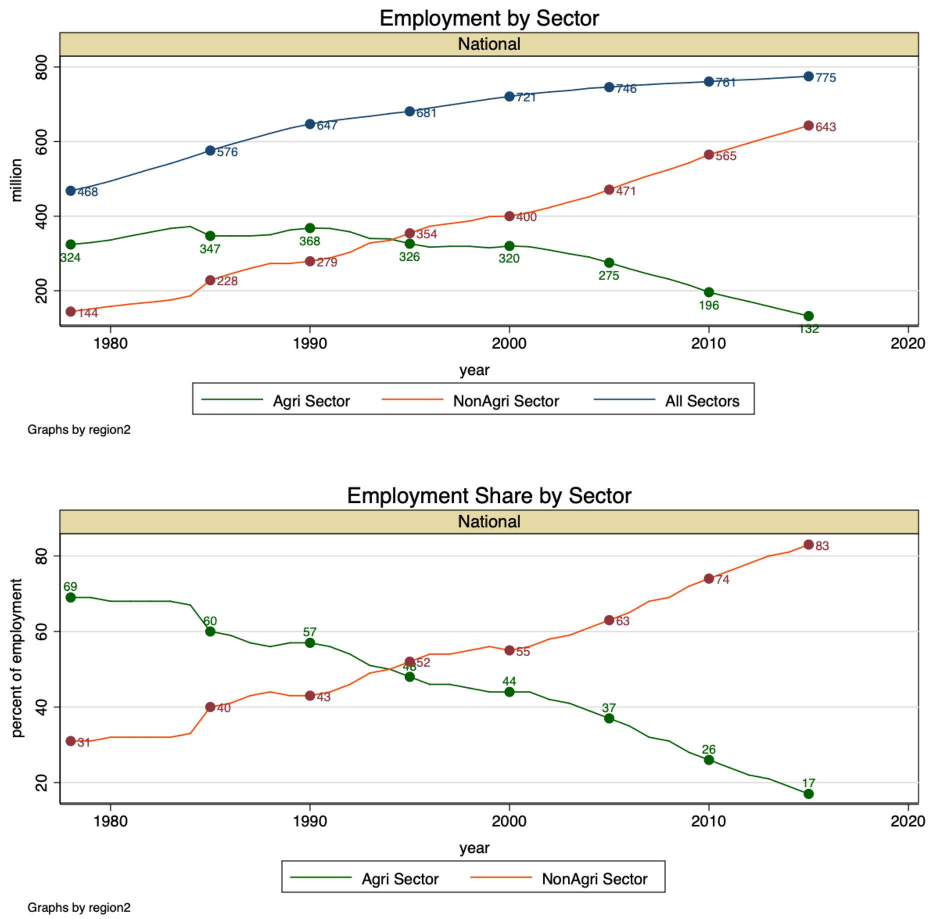
2.2.3 Employment and Employment Share by Sectors

Figure 2 shows the level and sectoral share of employment at the national and regional levels. At the national level, nonagricultural employment rose from 144 million (31% of the employment) in 1978 to 643 million (83% of the employment) in 2015. This implies that around half of the labor force switched out of agricultural

[4]2015 provincial employment is estimated by 2010 provincial employment level times the 2010-2015 growth rate obtained fro each of the provincial yearbooks. When calculating the 2010-2015 growth rate from provincial yearbooks, the provincial employment is adjusted such that provincial sum equals the national employment reported in the Chinese Statistic Yearbook.

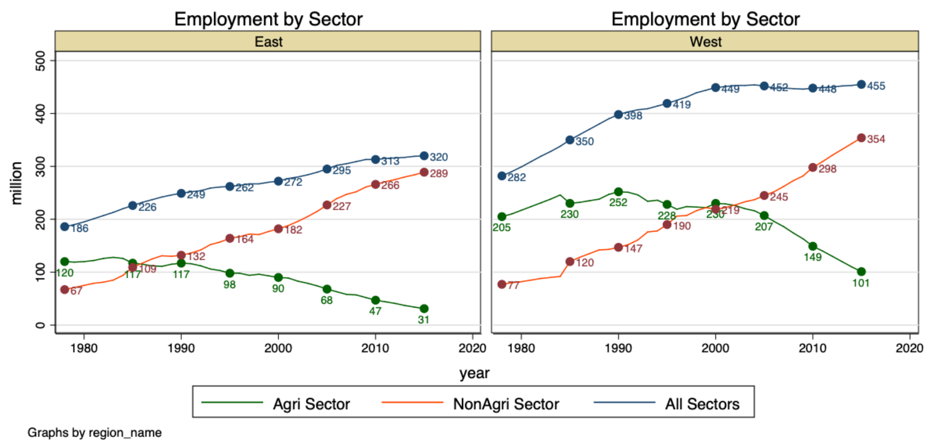
sector.

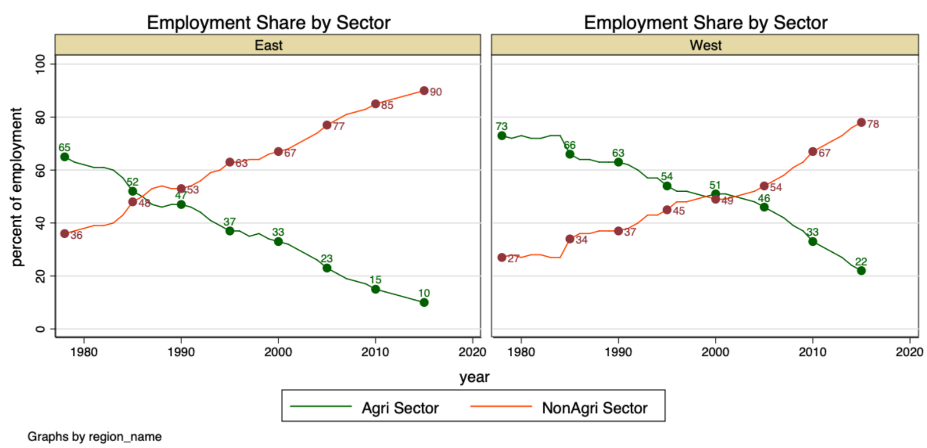
Figure 2: National Employment by sector



In figure 3, the same trend holds at the regional level, but structural transformation takes place at a different pace. Despite a smaller employment size of the Eastern region, the Eastern structural transformation starts earlier than the Western region. In the Eastern region, nonagricultural employment share is as large as 36% in 1978 and increases to 90% in 2015. In the Western region, although nonagricultural employment share increased by 51%, half of the increase took place in the first 26 years and the other half in the last 11 years after 2004. The Eastern region

Figure 3: Regional Employment by sector





is lagging by around 15 years in terms of structural transformation.

To access the regional contribution to overall structural transformation, I decompose the national nonagricultural employment growth rate into the contribution from the two regions (denoted as region j). The following equation shows that the percentage change of national employment can be decomposed into weighted regional summation. The regional contribution is simply a percentage change of regional nonagricultural employment times the regional employment share.

$$
\begin{aligned}
\%\Delta Emp_t^{National} &= \frac{Emp_t^{National} - Emp_{t-1}^{National}}{Emp_t^{National}} \\
&= \sum_j \frac{Emp_t^j - Emp_{t-1}^j}{Emp_t^j} \times \frac{Emp_t^j}{Emp_t^{National}} \\
&= \sum_j (\%\Delta Emp_t^j \times Reginal\,Emp\,Share_t^j)
\end{aligned}
$$

Table 1: Nonagricultural employment growth decomposition

Year	National		East		West	
	growth	contribution	growth	contribution	growth	contribution
1980-1990	43.49%	100.00%	43.11%	47.00%	43.84%	53.00%
1990-2000	30.30%	100.00%	28.33%	43.12%	31.99%	56.88%
2000-2010	29.08%	100.00%	30.63%	49.65%	27.70%	50.35%

Table 1 presents 10-year nonagricultural employment growth and the regional decomposition. In the 1980-1990 period, nonagricultural employment in the two regions grows at a similar rate. In 1990-2000, the West grows relative faster and in 2000-2010, the East grows faster. Although the structural transformation took place late in the West, the contribution from the West is higher due to a larger West labor force.

2.3 Migration Data and the Census

In this subsection, I discuss the inconsistency in the sectoral employment measure between the census and yearbook. I then discuss possible reasons for inconsistency and potential bias of migration data. Finally, I present the details of migration flow measures.

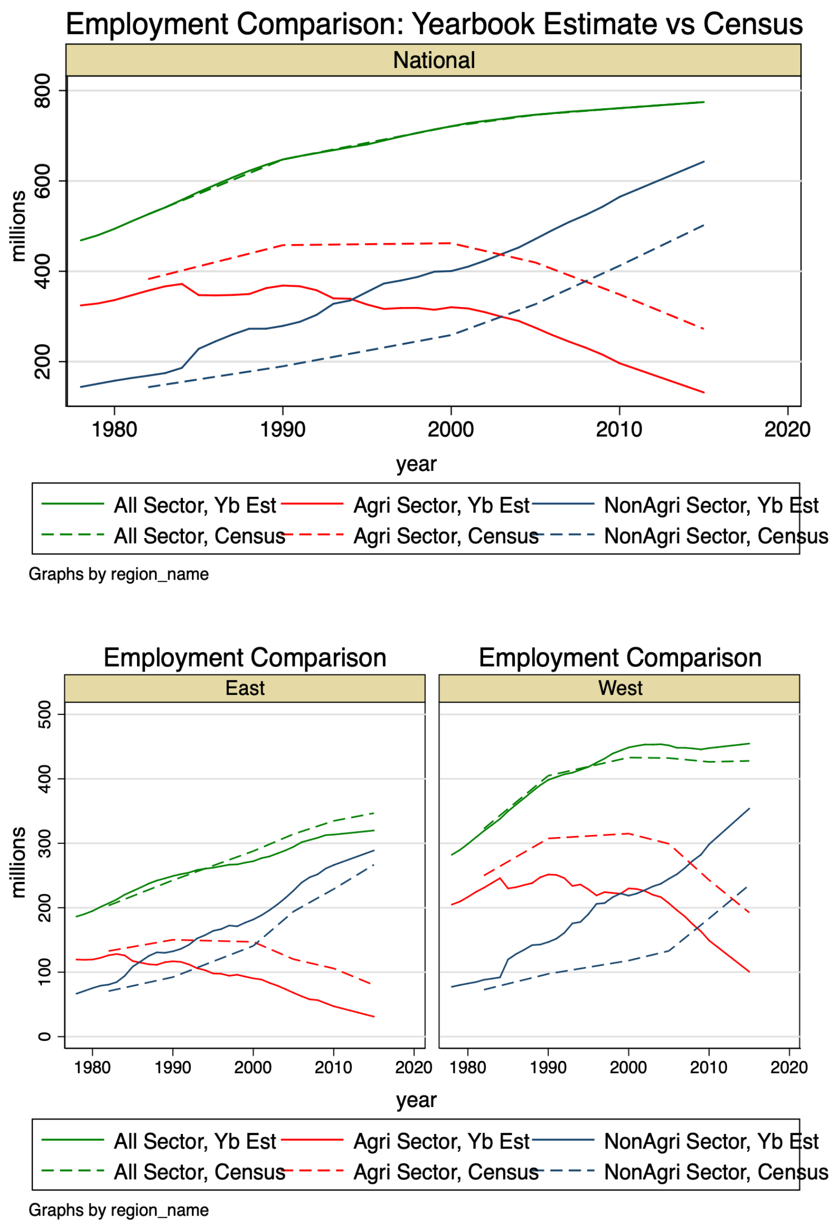
I obtain regional level migration data from 1982, 1990, 2000, 2010 Population Censuses and 2005, 2015 1% Population Sample Survey that allow me to track worker occupation, work destination, hukou origin, and hukou type. Workers are at least 16 years old and report an occupation, which is consistent with the Yearbook definition of employment.

The 2000 census-reported agricultural employment (462 million) is much higher than the measure I estimate from the Yearbook (320 million) (figure 4)[5]. I follow Holz (2006) and cross-reference these figures with the 1996 Agricultural Census, which reports 311.5 million full-time farmers and 126.67 million part-time farmers. The 1996 Agricultural Census' total farmer count is close to that of the census-reported figure, and its full-time farmer count is similar to my Yearbook estimate. Therefore, I infer that the census uses a broader definition of agricultural employment, which counts both full-time farmers and part-time farmers as agricultural producers whereas my Yearbook estimate includes only full-time farmers. Therefore, the gap between the census and Yearbook estimates should be the number of part-time farmers.

Figure 4 compares the employment measures between my Yearbook estimate and the census. At the national level, my Yearbook estimate of nonagricultural employment starts increasing rapidly in 1985, while the census measure only starts growing rapidly in 2000. In the regional comparison, the Yearbook estimates of

[5] The two datasets are collected differently. The census data is collected by the census survey team whereas the Yearbook data are reported by the *Labor Force Survey System*, where employment is reported at different statistical levels. The two systems define one's sector differently especially farmers doing off-farming works.

Figure 4: Yearbook Estimates and Census Comparison



nonagricultural employment trends between East and West are similar, while the census' are not. The census nonagricultural employment grows rapidly in the Eastern region between 2000 and 2010, while it only begins increasing rapidly in the Western region after 2005. As a result, the gap between the census and Yearbook estimate measures is bigger in the West. This gap is contributed by part-time farmers. Recall that part-time farmers are counted under agricultural employment in the census and under nonagricultural employment in my Yearbook estimate. The large number of part-time farmers in the West is due to bigger agricultural employment size in the Western region.

Since I estimate the number of migrants using census data, I may underestimate migrants in the nonagricultural sector and overestimate migrants in the agricultural sector. I may also underestimate the number of job-switchers who switch from being farmers to workers without relocation, especially in the Western region. Underestimating migrants may undermine my main result.

2.3.1 Migration Trend

To understand how migration contributes to regional and national structural transformation, I focus on migration out of agriculture and across regions. To obtain a consistent migration flow across different waves of the census, a migrant worker is a worker[6] who moved out of his home county[7] within the past five years and for at least 6 months. In this section, I first discuss the number of migrants in the literature, and then I discuss the number of migrant workers obtained from the census.

In the literature, the number of migrants from both survey data and NBS reports are extensively cited. Migration surveys provide rich details such as migration decisions and detailed migration patterns, but are usually one-time surveys and do not

[6]In the census data, I limit workers to those over 16 years old and have an occupation, same definition in the Yearbook. In 2000, 56% of the population are workers.

[7]There are 709 commuting zones delineated for the U.S. In China, there are 333 prefectures and 2860 counties. Given that the two countries are close in geographical size, county is a good definition to distinguish migrants from non-mover in China. The main reason to choose county as the migration boundary is that 1990 census only distinguish migrant if one resides out of county.

provide sufficiently detailed region-level long-term changes (Zhao, 1999; Rozelle et al., 1999; Taylor et al., 2003; Meng, 2012). NBS reports, on the other hand, span for longer periods but only provide aggregated migration stock (Cai et al., 2011; Chan, 2008,0). Chan (2012 Table 1 column C-D) shows the widely cited Report of National Population Census/1% Population Sample Survey. It reports only aggregate population migration without distinguishing workers from non-workers, with as many as 261 million migrants who moved outside of their hukou town for at least 6 months in 2010, which comprises 19% of the population.

Migration stock from the micro census give us a more detailed migration pattern of workers, however, the migration flow between regions is less clear under this measure. Fortunately, the micro census data provides a 5-year migration flow from 1990 to 2015, capturing labor relocation since the emergence of migrating for work. It also provides rich information on the origin and destination of each migrant, their occupation and hukou type which can be used as an approximation for their previous job. Since I only look at migration of the employed, the migrants would be a subset of the total population migrant.

Assuming 5-year-migrants with Agri hukou worked in the agricultural sector before they move, I define **out-of-agriculture migrants** as those who have Agri hukou but now work in the nonagricultural sector. To capture regional relocation, I define between- and within-region migrants as follows.

[1] **Between-region 5-year-migrants with Agri hukou**: any worker with Agri hukou who works in the nonagricultural sector resided in another region 5 years ago.

[2] **Within-region 5-year-migrants with Agri hukou**: any worker with Agri hukou who works in nonagricultural sector resided in the same (East/West) region but not the same county 5 years ago.

[3] **5-year increment of within-region sector switchers**: sector switchers are any worker with agriculture hukou who works in the nonagricultural sector without relocation. I only look at the 5-year increment of these switchers.

[4] Net flow of between-region 5-year-migrants with NonAgri hukou. This channel only affects regional employment, not national employment. In later discussion, I find significantly fewer of these migrants compared to [1]-[3].

The first two definitions show how migration contributes to structural transformation. The third definition captures the contribution of job-switchers without relocation. All three channels capture workers shifting from the agricultural sector to nonagricultural sector.

However, the second channel may overestimate the number of migrants. Recall the strong assumption that all 5-year migrants with Agri hukou were in agricultural sector before they move. If they were already in nonagricultural sector, I will overestimate the number of migrants. Besides, the following two potential contributors are not captured by the census migration data.

[5] Part-time workers that are counted as agriculture producers in the census but counted as workers in my Yearbook estimate are not categorized as nonagricultural workers here.

[6] The net of young workers entering the secondary or tertiary sectors less old workers exiting the nonagricultural sector.

In summary, the increment of nonagricultural sector is contributed by between-migrant with both hukou [1][4], within-migrant with Agri hukou [2] and 5-year increment of job-switchers [3].

Three reasons may lead to mis-measurement of the migrants and job-switchers that contribute to the nonagricultural employment increment. Firstly, within-migrant with Agri hukou [2] may lead to an overestimation of migrants. If Agri hukou within-migrant was already in nonagricultural sector 5 years ago, then I am overestimating the migrants who contribute to nonagricultural sector. Secondly, the part-time workers [5] not captured by the census data may also contribute to the nonagricultural employment growth. This may lead to an underestimation of the number of job-switchers [3]. Thirdly, demographic structure [6] is not considered.

If entering young workers excess exciting old workers in the nonagricultural sector, the nonagricultural employment will grow absent of migration, vice versa.

A note of caution is that the 2015 census does not report hukou type. Instead, it asks if the individual is entitled to land rights. Since the share of land rights holders in 2015 is lower than the expected share of Agri hukou holders, we are likely to underestimate (overestimate) the number of Agri hukou (NonAgri hukou) migrants and thus their contribution to sectoral employment growth.[8] To correct the 2015 hukou measurements, I perform the following adjustments. Given that the total number of migrants in 2015 is correct, I assign the hukou ratio from 2010 to the 2015 migrants for both within and between migration categories.

2.3.2 Migration Flow

This subsection first presents the migration flow calculated from the census. Then, I study how migrants and job-switchers contribute to the growth of nonagricultural employment every five years.

Table 2 presents the migration flow every five years and compare it with the nonagricultural employment increment estimated from Yearbook. The column "total migrant" is the sum of four channels that contribute to structural transformation. The percentage number under migration is the ratio of that migration type to the nonagricultural employment increment, which is a measure of migration contribution.

At the national level, total migration flow increased by 5 folds from 1990 to 2015. Total migration and job-switchers account for three-quarters to five-quarters of the nonagricultural employment increment[9]. The U-shaped job-switchers is the

[8] The hukou type has minor changes over time. In the Census, 80.05% of labor report Agri hukou in 1990, 79.59% in 2000, 77.03% in 2005, 76.73% in 2010 and 65.87% (entitles land right) in 2015. A simple linear regression on earlier years would predict the 2015 NonAgri hukou share to be 75.85%. Compare to earlier years, the land right measure gives 10.02% more NonAgri hukou workers.

[9] The estimated 1995 migration does not capture yearly fluctuation, so the reported migration

Table 2: Migration Flow every 5 year (millions)

year	Employment			Migrant Flow				
	Ag Emp	NAg Emp	NAg	Between		Within	Switcher	Total
			Increment	Ag hukou [1]	NAg hukou [4]	Ag hukou [2]	Ag hukou [3]	
National								
1990	368.39 m	279.10 m	50.77 m	1.61 m 3.18%	1.33 m 2.62%	7.11 m 14.01%	26.31 m 51.82%	36.37 m 71.64%
1995	326.38 m	354.27 m	75.17 m	7.88 m 20.19% [a]	1.65 m 3.50%	6.73 m 17.63%	13.62 m 23.14%	29.88 m 64.45%
2000	320.41 m	400.44 m	46.17 m	16.62 m 20.19%	2.59 m 3.50%	14.66 m 17.63%	14.45 m 23.14%	48.33 m 64.45%
2005	274.97 m	471.50 m	71.06 m	25.04 m 35.23%	4.23 m 5.95%	33.82 m 47.60%	24.67 m 34.72%	87.76 m 123.50%
2010	196.38 m	564.67 m	93.17 m	29.43 m 31.59%	3.73 m 4.00%	34.34 m 36.86%	33.29 m 35.74%	100.79 m 108.18%
2015	131.78 m	642.73 m	78.06 m	20.86 m 26.72%	2.69 m 3.45%	27.67 m 35.44%	24.07 m 30.84%	75.29 m 96.45%
East								
1990	116.87 m	132.35 m	23.76 m	1.03 m 4.31%	0.95 m 3.98%	3.63 m 15.27%	16.45 m 69.22%	22.05 m 92.78%
1995	98.00 m	164.09 m	31.74 m	7.31 m 47.11% [a]	1.25 m 7.09%	1.63 m 20.26%	9.12 m 33.51%	19.31 m 107.97%
2000	90.41 m	181.75 m	17.66 m	15.97 m 47.11%	2.25 m 7.09%	8.38 m 20.26%	7.43 m 33.51%	34.04 m 107.97%
2005	67.99 m	226.57 m	44.82 m	24.17 m 53.93%	3.87 m 8.62%	24.78 m 55.29%	11.20 m 24.99%	64.02 m 142.84%
2010	47.15 m	266.28 m	39.71 m	28.11 m 70.79%	3.07 m 7.74%	17.82 m 44.88%	16.85 m 42.44%	65.85 m 165.85%
2015	31.06 m	288.77 m	22.49 m	14.98 m 66.60%	1.66 m 7.38%	16.75 m 74.46%	3.13 m 13.91%	36.52 m 162.35%
West								
1990	251.52 m	146.75 m	27.00 m	0.59 m 2.18%	0.39 m 1.43%	3.49 m 12.91%	10.00 m 37.04%	14.46 m 53.56%
1995	228.38 m	190.18 m	43.43 m	0.59 m 1.73% [a]	0.38 m 1.01%	5.10 m 15.82%	4.52 m 16.01%	10.60 m 34.56%
2000	230.00 m	218.69 m	28.51 m	0.65 m 1.73%	0.34 m 1.01%	6.28 m 15.82%	6.99 m 16.01%	14.27 m 34.56%
2005	206.98 m	244.93 m	26.24 m	0.87 m 3.30%	0.36 m 1.39%	9.04 m 34.46%	13.47 m 51.33%	23.74 m 90.48%
2010	149.23 m	298.39 m	53.46 m	1.32 m 2.47%	0.65 m 1.22%	16.52 m 30.90%	16.44 m 30.76%	34.94 m 65.35%
2015	100.72 m	353.96 m	55.57 m	4.51 m 8.11%	2.40 m 4.32%	10.92 m 19.65%	20.95 m 37.70%	38.77 m 69.78%

* The sectoral employment data is estimated from Yearbooks. Migration flow is 5-year migration flow reported by micro census.
a. Migration data in 1985, 1995 is extrapolated from 1982, 1990-2015 census using STATA spline. Therefore, the 1995 and 2000 migration contributions are the average of the two period.

largest migration group and is important especially before 1995 and after 2005. Between-migrants that peaks in 2010 are mainly migrants from the Western to the Eastern region. The between-migrants with Agri hukou contribute to structural transformation in both regions by reducing agricultural employment in the Western region and increasing nonagricultural employment in the Eastern region. Within-migrants are contributed by both the Eastern and the Western region. The inverse U-shaped job-switchers and the U-shaped migrants picture the trend of labor reallocation. Before 1990, people switched from agriculture to nonagriculture within their home county. Then migration restriction is released and people relocate to other cities and other regions. After 2010, people with Agri hukou choose to work in home county but in the nonagricultural sector.

In the Eastern region, migration and job-switchers account for around 93% to 166% of the nonagricultural employment increment for most of the years. Among them, the contribution from job-switchers declined from two thirds to 14%. Between migrants with Agri hukou peaks at 28 million in 2010, which accounts for three-quarters of the nonagricultural employment increment. After 2010, between-migrants decrease and drive down the national between-migrants. The within-migrants peak in 2005 and then declined.

In the Western region, total migrants can only explain a part of the nonagricultural employment increment suggesting the un-captured part-time farmer plays a role. Within-migrants are more important than between-migrants. Within-migrants increase to 17 million in 2010, which accounts for one-third of the nonagricultural employment increment in the Western region. Job-switchers account for less than half of the nonagricultural employment increment most of the time. After 2010, the number of job-switchers increased while within-migrants decrease, which could be a result of hukou policy change. In 2014, the national government not only eliminates the distinction between Agri and NonAgri hukou but also encourage non-farming individuals to join neighboring towns. Therefore, more job-switchers and fewer within-switchers are observed. At the same time, more between-migrants are

contribution in 1995 and 2000 are averaged between the two years.

observed, which is a sign of return-migration.

In some of the years, the total migrants exceed the number of nonagricultural employment increment, especially in the Eastern region. As discussed in section 2.2.3, this is due to the strong assumption on migrants with Agri hukou. If a within-migrant worker was already in nonagricultural sector before they relocate, they would be mistakenly counted as migrants. In the early years where the contribution is smaller than 100%, the census underestimates job-switchers by not including part-time workers. But the number of between-migrants does not suffer from this problem and is accurately measured.

Measuring migrants is important. The number of migration generates calculate migration cost and counterfactuals in the next section. In the model, I will use the accurately measured between-migrants data for regional labor relocation.

3 Model Labor Reallocation

This section present a 2-region 2-sector model with labor input. Following the model, I calibrate the model and run counterfactuals to access the the effect of migration barriers on output and welfare.

3.1 Production

Production function of region $i = \{east, west\}$ and sector $j = \{agri, nonagri\}$ is

$$Y_{ij} = A_{ij} L_{ij}.$$

Profit maximization problem is:

$$\max_{L_{ij}} \{p_{ij} A_{ij} L_{ij} - w_{ij} L_{ij}\}.$$

The first order condition gives

$$p_{ij} = \frac{w_{ij}}{A_{ij}}. \tag{1}$$

3.2 Consumption

In region i, worker in sector j has utility U_{ij} and consumption C_{ij}. Superscript denote the consumption good (agriculture or nonagriculture good). Representative worker's utility is Stone-Geary:

$$\max_{c^a_{ij}, c^n_{ij}} U_{ij} = log(\varepsilon_{ij} C_{ij}) = \varepsilon_{ij} + \theta log(c^a_{ij} - \bar{a}) + (1-\theta) log(c^n_{ij})$$

$$s.t.\ p_{ia} c^a_{ij} + p_{in} c^n_{ij} = w_{ij}$$

ε_{ij} is the idiosyncratic location-sector preference shifter that is i.i.d across workers, sectors and regions. ε_{ij} would help us to pin down the migration fraction in the next section. θ is preference on agriculture good consumption. Ratio of two first order conditions is $\frac{\theta}{1-\theta} \frac{c^n_{ij}}{c^a_{ij} - \bar{a}} = \frac{p_{ia}}{p_{in}}$, together with budget constraint gives:

$$c^a_{ij} = \frac{\theta w_{ij}}{p_{ia}} + (1-\theta)\bar{a}, \tag{2}$$

$$c^n_{ij} = \frac{(1-\theta) w_{ij}}{p_{in}} - (1-\theta) \frac{p_{ia}}{p_{in}} \bar{a}. \tag{3}$$

As a result, aggregate consumption index of worker in region i sector j is

$$C_{ij} = (c^a_{ij} - \bar{a})^{\theta} (c^n_{ij})^{1-\theta} = \left(\frac{\theta}{p_{ia}}\right)^{\theta} \left(\frac{1-\theta}{p_{in}}\right)^{1-\theta} (w_{ij} - p_{ia}\bar{a}).$$

3.3 Migration

Worker differ in their location preference ε_{ij}, which is i.i.d across workers, sectors and regions. Worker in region-sector ij would move to region-sector kl if they can get a higher utility in kl. Follow Redding (2016) and Tombe and Zhu (2019), the proportion of workers who migrate from ij to kl is:

$$m_{ij,kl} = Pr\left(\varepsilon_{kl}C_{kl}/\eta_{ij,kl} \geq \max_{k'l'}\{\varepsilon_{k'l'}C_{k'l'}/\eta_{ij,k'l'}\}\right),$$

where $\eta_{ij,kl}$ is migration cost if one move from ij to kl. If idiosyncratic term ε_{ij} follows Fréchet distribution with CDF $\varepsilon_{ij} = F_{\varepsilon}(x) = e^{-x^{-\kappa}}$ where larger location preference dispersion κ means smaller dispersion, Proposition 1 in Tombe and Zhu (2019) suggests migration share can be obtained:

$$m_{ij,kl} = \frac{(C_{kl}/\eta_{ij,kl})^{\kappa}}{\sum_{k'}\sum_{l'}(C_{k'l'}/\eta_{ij,k'l'})^{\kappa}}.$$

Migration ratio of workers migrant from ij to kl to the non-migrants is:

$$\frac{L_{ij,kl}}{L_{ij,ij}} = \frac{m_{ij,kl}}{m_{ij,ij}} = \left(\frac{C_{kl}}{C_{ij}} \times \frac{1}{\eta_{ij,kl}}\right)^{\kappa}. \tag{4}$$

3.4 Utility Gap

This subsection introduces the utility wedges μ_i within region i between the two sectors, and utility wedge η between two regions.

3.4.1 Within Region Utility Gap

In region i, let $\mu_i \in (0,1)$ be utility wedge such that farmer's utility is lower than workers by μ_i in region i. A higher μ_i represents a bigger utility gap:

$$C_{ia} = (1-\mu_i)C_{in} \tag{5}$$

The utility relationships gives the corresponding wage relationships. Equation (5) together with (2) - (3) give the within-region wage gap:

$$(w_{ia} - p_{ia}\bar{a}) = (1-\mu_i)(w_{in} - p_{ia}\bar{a}). \tag{5'}$$

For convenience, normalize agriculture good price in west region $p_{wa} = 1$, then equation (1) implies $w_{wa} = A_{wa}$. But regional price relationship is not solved. If I assume agriculture good price in east region $p_{ea} = 1$, equation (2), (3) and (1) allow prices to be a function of A_{ij}, μ_i, and $\bar{a}$. The condition $w_{ia} > \bar{a}$ should hold.

Table 3: Equilibrium Price

Worker Sector	Western Region	Eastern Region
agriculture worker	$p_{wa} = 1$	assume $p_{ea} = 1$
nonagriculture worker	$p_{wn} = \frac{A_{wa} - \mu_w \bar{a}}{(1-\mu_w)A_{wn}}$	$p_{en} = \frac{A_{ea} - \mu_e \bar{a}}{(1-\mu_e)A_{en}} \times p_{ea}$

3.4.2 Between Region Utility Gap

Let L_m be the number of migrants from west agricultural sector to east nonagricultural sector and let $\eta = \eta_{wa,en}$ be the corresponding migration cost. Equation (4) suggests that the share of migrants is a function of utility ratio and migration cost:

$$\pi = \frac{L_m}{L_{wa}} = \frac{L_{wa,en}}{L_{wa,wa}} = \left(\frac{C_{en}}{C_{wa}} \times \frac{1}{\eta} \right)^{\kappa} \tag{6}$$

$$= \left(\left(\frac{p_{wa}}{p_{ea}} \right)^{\theta} \left(\frac{p_{wn}}{p_{en}} \right)^{1-\theta} \times \frac{w_{en} - p_{ea}\bar{a}}{w_{wa} - p_{wa}\bar{a}} \times \frac{1}{\eta} \right)^{\kappa} \tag{6'}$$

$$= \left(\left(\frac{p_{wn}}{p_{wa}} \right)^{1-\theta} \left(\frac{p_{en}}{p_{ea}} \right)^{\theta-1} \times \frac{(p_{en}/p_{ea})A_{en} - \bar{a}}{A_{wa} - \bar{a}} \times \frac{1}{\eta} \right)^{\kappa}$$

$$= \left(\left(\frac{A_{wa} - \mu_w \bar{a}}{(1-\mu_w)A_{wn}} \right)^{1-\theta} \left(\frac{A_{ea} - \mu_e \bar{a}}{(1-\mu_e)A_{en}} \right)^{\theta-1} \times \frac{\frac{A_{ea} - \mu_e \bar{a}}{(1-\mu_e)A_{en}} A_{en} - \bar{a}}{A_{wa} - \bar{a}} \times \frac{1}{\eta} \right)^{\kappa} \tag{6''}$$

Rewrite equation (6'), between-region migration wedge η is calcualted from migration share from the census and wages, which is approximated with average revenue product:

$$\eta = \left(\frac{p_{wa}}{p_{ea}} \right)^{\theta} \left(\frac{p_{wn}}{p_{en}} \right)^{1-\theta} \times \frac{w_{en} - p_{ea}\bar{a}}{w_{wa} - p_{wa}\bar{a}} \times \left(\frac{L_m}{L_{wa}} \right)^{-1/\kappa}.$$

3.5 Market Clearing

Assume there is no trade between two regions, therefore, people only consume good produced in the same region. Market clearing conditions[10] for agriculture and nonagriculture goods within each region are:

$$c_{ia}^{a}L_{ia}+c_{in}^{a}L_{in}=Y_{ia} \tag{7}$$

$$c_{ia}^{n}L_{ia}+c_{in}^{n}L_{in}=Y_{in}. \tag{8}$$

Equation (7) or (8) gives sectoral labor decomposition within a region. In the eastern and western region:

$$\pi_e=\frac{L_{ea}}{L_{en}}=\frac{L_{ea}}{\bar{L}_{en}+L_m}=\frac{\theta(A_{ea}-\mu_e\bar{a})/(1-\mu_e)+(1-\theta)\bar{a}}{(1-\theta)(A_{ea}-\bar{a})} \tag{7'}$$

$$\pi_w=\frac{L_{wa}}{L_{wn}}=\frac{\theta(A_{wa}-\mu_w\bar{a})/(1-\mu_w)+(1-\theta)\bar{a}}{(1-\theta)(A_{wa}-\bar{a})} \tag{8'}$$

where $L_m=L_{wa,en}$ is the number of migrant workers who moved from west agriculture to east nonagriculture and $\bar{L}_{en}$ is the original east nonagricultural workers. Therefore, final east nonagricultural employment is $L_{en}=\bar{L}_{en}+L_m$. The overall labor constraint is

$$L_{wa}+L_{wn}+L_{ea}+L_{en}=L. \tag{9}$$

I have four equations (6”), (7’), (8’), and (9) and five unknowns $L_{wa},L_{wn},L_{ea},L_{en},L_m$. To solve for regional employment allocation, let $\bar{L}_{ij}$ be the employment allocation before migration[11] and L_{ij} be the employment after migration. Denote the employment ratio in equation (6’) (7’) (8’) as follow:

$$\pi=\frac{L_m}{L_{wa}},\ \pi_e=\frac{L_{ea}}{L_{en}},\ \pi_w=\frac{L_{wa}}{L_{wn}}.$$

[10](2) and (3) reduce to the same equation due to budget constraint.

[11]Use hukou type to approximate for employment before migration

L_{ij} employment has the following relationship:

$$
\begin{aligned}
L_m &= \pi \cdot L_{wa}, \\
L_{wn} &= \bar{L}_{wa} + \bar{L}_{wn} - L_{wa} - L_m, \\
L_{wa} &= \pi_w \cdot L_{wn} = \pi_w(\bar{L}_{wa} + \bar{L}_{wn} - L_{wa} - L_m); \\
L_{en} &= \bar{L}_{ea} + \bar{L}_{en} - L_{ea} + L_m, \\
L_{ea} &= \pi_e \cdot L_{en} = \pi_e(\bar{L}_{ea} + \bar{L}_{en} - L_{ea} + L_m).
\end{aligned}
$$

Given estimated share $\hat{\pi}$, $\hat{\pi}_e$, $\hat{\pi}_w$ and original employment $\bar{L}_{ij}$, I can solve for L_{ea}, L_{en}, L_{ea}, L_{en} and L_m:

$$
\begin{aligned}
L_{wa} &= \frac{\hat{\pi}_w}{1 + (1+\hat{\pi})\hat{\pi}_w}(\bar{L}_{wa} + \bar{L}_{wn}) \\
L_{wn} &= \frac{1}{1 + (1+\hat{\pi})\hat{\pi}_w}(\bar{L}_{wa} + \bar{L}_{wn}) \\
L_m &= \frac{\hat{\pi}\hat{\pi}_w}{1 + (1+\hat{\pi})\hat{\pi}_w}(\bar{L}_{wa} + \bar{L}_{wn}) \\
L_{ea} &= \frac{\hat{\pi}_e}{1 + \hat{\pi}_e}(\bar{L}_{ea} + \bar{L}_{en} + L_m) \\
L_{en} &= \frac{1}{1 + \hat{\pi}_e}(\bar{L}_{ea} + \bar{L}_{en} + L_m)
\end{aligned}
$$

3.6 Equilibrium

Definition: The competitive equilibrium is a set of prices $\{p_{ij}\}$, output $\{Y_{ia}\}$, consumptions $\{c^a_{ij}, c^n_{ij}\}$, employments $\{L_{ij}\}$ such that producer profit and consumer utility are maximized (1-3 holds) and market clearing conditions (7)-(9) are met. The corresponding labor allocation $\{L_{ij}\}$ is the competitive allocation.

3.7 Calibration

Region-sector TFP $A_{ij} = Y_{ij}/L_{ij}$ is exogenously given by equation (1). To calibrate the model, parameters $\bar{a}$, μ_i, η, θ and κ are needed. I first pick $\bar{a}$, which is constant over time. Then I calculate time-varying μ_i from equation (5') and sectoral average products. With $\bar{a}$, μ_i chosen, I find the θ that gives the closest agricultural employment share in the data. Parameter $\kappa = 10$ is selected. I calculate η from (6') with migration data.

3.7.1 Subsistence consumption $\bar{a}$

Piazza (1983) calculated subsistence consumption and the food availability from 1950 to 1981. In 1978, the total energy per capita is 2370.08 Calories, which is 109.73% of the energy requirement. Since the agriculture production is $Y_a = A_a L_a$, production per person is A_a, then total agriculture production is $A_a L_a$ and total energy requirement is $\bar{a}L$. I have:

$$\frac{\text{total energy}}{\text{total requirement}} = 109.73\%$$
$$\frac{A_{a1978} \times L_{a1978}}{\bar{a} \times L_{1978}} = 109.73\%$$

Given that in 1978, agriculture workers are 64% of the labor force, the above equation suggest $\bar{a} = 64\% A_a$.

3.7.2 Consumption Preference θ

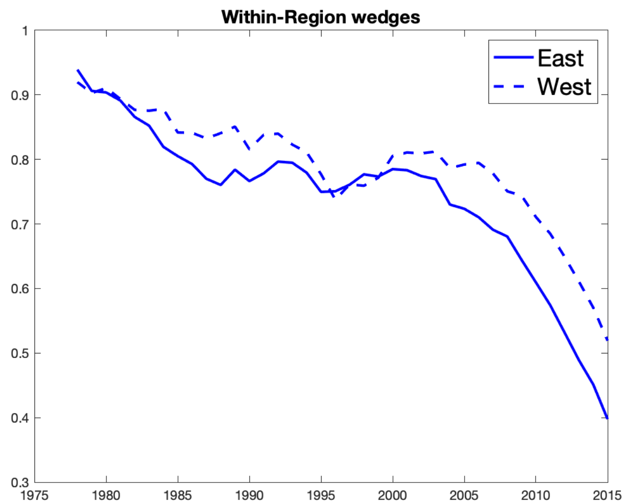
θ is the consumption preference parameter for agriculture good. I calibrate the model such that θ minimizes the distance between the agricultural employment share in the model and data. The calibration suggests θ is 9.26%. The calibrated agricultural employment share are close to the data (see Appendix).

3.7.3 Within-Region Migration wedge μ_i

For a time-varying μ_i, I use equation (5') to back out the μ_i in each period:

$$\begin{aligned} \mu_i &= 1 - \frac{w_{ia} - p_{ia}\bar{a}}{w_{in} - p_{ia}\bar{a}} \\ &= 1 - \frac{A_{ia} - \bar{a}}{(p_{in}/p_{ia})A_{in} - \bar{a}}. \end{aligned}$$

Figure 5:



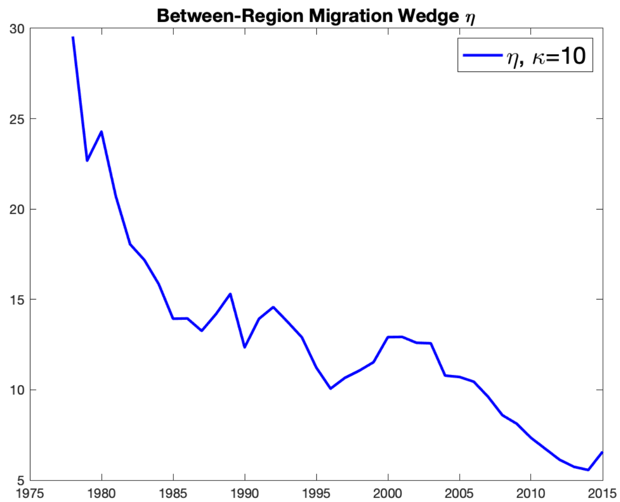
I use agriculture and nonagriculture average revenue product from the data to approximate for w_{ia} and w_{in}. Alternatively, the fact that $w_{ij} = p_{ij}A_{ij}$ allows μ_i to be estimated from true price ratio p_{in}/p_{ia} and A_{ij}.

Figure 5 suggests that within-region migration wedges μ_is have decreasing trend in general. Migration wedge in the east region is lower than the west region, which indicates less labor distortion in the east region. Both wedges fall rapidly before 1990, then they becomes volatile for 10 years before they significantly fall again.

3.7.4 Between-Region Migration wedge η

Recall that cross-region migrants has Fréchet distributed preference, where parameter κ is the degree of location preference dispersion across individuals. A larger κ implies small preference dispersion. In the literature that focus on provincial level dispersion, κ is roughly in the range (1, 3). Since I am studying at a more aggregated level, I pick larger κ and let κ=10.

Figure 6:



In equation (6'), η takes both net wage ratio and migration share into account:

$$\eta = \left(\frac{p_{wa}}{p_{ea}}\right)^{\theta} \left(\frac{p_{wn}}{p_{en}}\right)^{1-\theta} \times \frac{w_{en} - p_{ea}\bar{a}}{w_{wa} - p_{wa}\bar{a}} \times \left(\frac{L_m}{L_{wa}}\right)^{-1/\kappa}.$$

Figure 6 suggests the between-region wedge is decreasing over time. Recall that the between-region wedge measures the migration barrier between Western agricultural and Eastern nonagricultural sector. Therefore, it reflects distortions both between two sectors and across two regions. The between wedge decline rapidly before 1990, then the decline becomes modest. In the last five years, the between wedge is rather constant.

As a summary, parameter values are presented inf table 4.

3.8 Counterfactuals

This subsection investigates the impact of forgone migration and migration wedges on the aggregated output and welfare by conducting a series of counterfactual experiments. Let the aggregate output be a simple summation of the sectoral and

Table 4: Parameters

Para	Description	Note
$\bar{a}$	0.64% A_{a1978}	subsistence consumption
θ	9.26%	preference on food
μ_i	estimated from yearly data	within-region utility gap
η	estimated from yearly data	between-region utility gap
κ	10	migration elasticity

regional outputs

$$Y = \sum_{ij} Y_{ij} = \sum_{ij} A_{ij} \hat{L}_{ij}.$$

Similarly, aggregate welfare is

$$W = \sum_{ij} \hat{C}_{ij} \hat{L}_{ij}.$$

To examine the effect of each channel, I compare each counterfactual outcome Y^{CF} and W^{CF} to the benchmark outcome Y and W. The relative output is measured by $ln(Y^{CF}/Y)$ and relative welfare is $ln(W^{CF}/W)$.

To evaluate the impact of migration on the outcomes, I run counterfactuals by restoring migrants to their home region and sector. Figure 7 suggests that when migration between regions and sectors is restricted, the output would be 34% lower and welfare by 21% lower in 2015. If only between-region migration is restricted, the output would be 15% lower and welfare would be 11% lower in 2015. Between-region migration is as important as within-region migration.

Despite large economic gain from forgone migration, the remaining migration barriers prevent labor from flowing to the most efficient region and sector. To understand how migration barriers impact the economy, I eliminate within-region wedges and between-region wedge one at a time. Let regional wedges $\mu_i = 0$ and national wedge $\eta = 1$, equation (6"), (7) and (8') give corresponding employment allocation $\hat{L}_{ij}$ and migration $\hat{L}_m$, and thus output and welfare.

Figure 7: Output Loss if no Migration

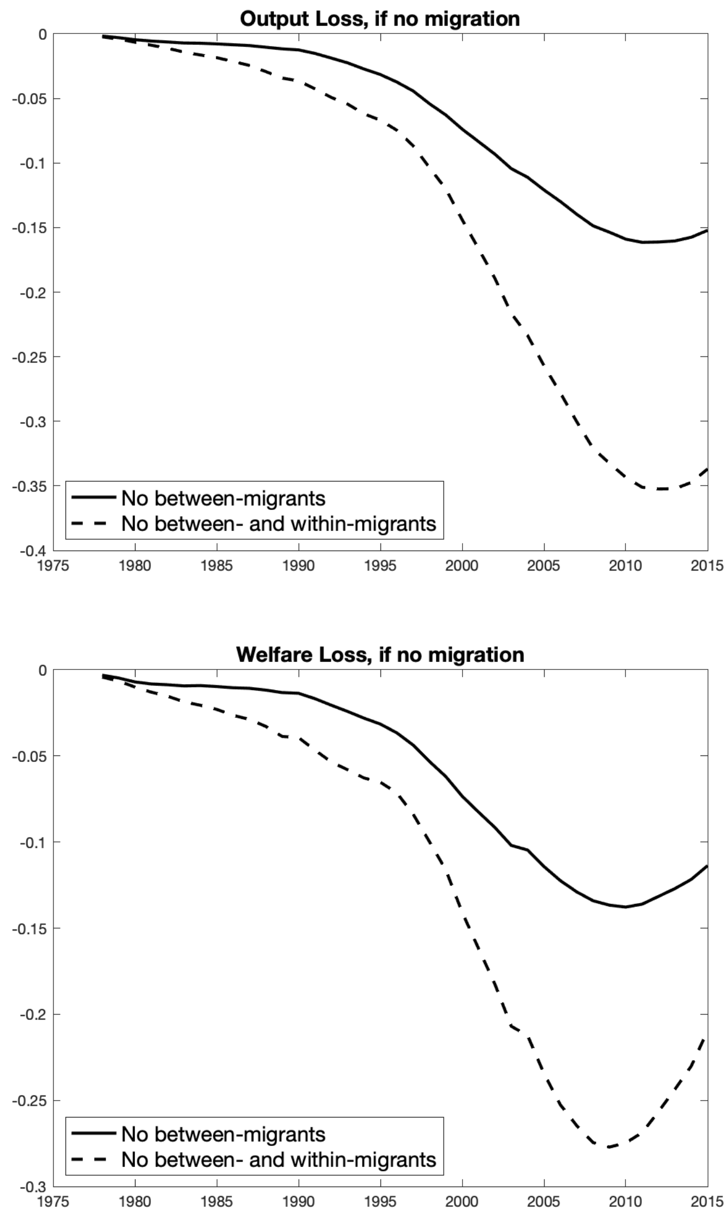


Figure 8 shows the potential gain of output and welfare. There are two main observations on the output gain. Firstly, the within-region output gain is increasing. Secondly, the between-region output gain is hump-shaped and is three times larger than the within-region output gain.

The first observation is intuitively explained by sectoral labor allocation in figure 10 where the gap of the employment shares (solid and dotted blue line) is widening over time. The reason is that as μ_i declines, agriculture labor share decrease at a speed of $\theta(1-\theta)(A_{ia}-\bar{a})^2$[12]. Since A_{ia} become larger in the later period, a small decrease in μ_i can lead to a larger decrease in agriculture labor share. In other words, although μ_i is smaller in the later period, eliminating one unit of μ_i can release more labor in the agricultural sector due to higher A_{ia} and thus lead to higher output gain. Therefore, in the later period, removing within-region barrier is very beneficial to the economy.

Secondly, the between wedge η reflects the welfare gap between Eastern nonagricultural sector and Western agricultural sector, therefore, it captures distortion both between-region and within-region. The observed "no between wedges" curve reflects both "no within wedges" and wedge between two regions. When between-region wedge is removed, large amount of migrants move from Western agriculture to East nonagriculture, which results in large gain in aggregate output and welfare. In 2015, the potential gain to output and welfare is as large as 24%.

Figure 9 further decomposes the within-region gain by the two regions. The no-within-west and no-within-east gain are obtained by removing corresponding within wedges. The potential gain from the Western region is slightly higher than the east because migration wedge is higher in the West.

[12] $\partial l_{ia}/\partial \mu_i = \theta(1-\theta)(A_{ia}-\bar{a})^2$

Figure 8: Potential Output and Welfare Gains

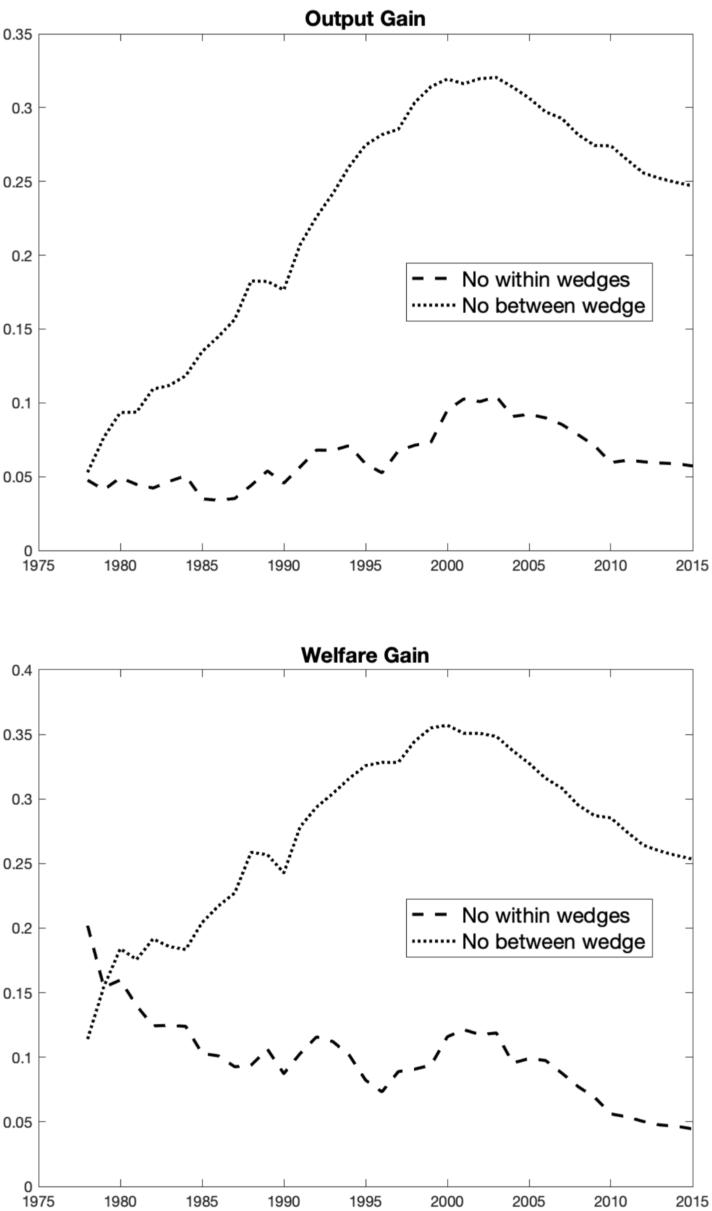
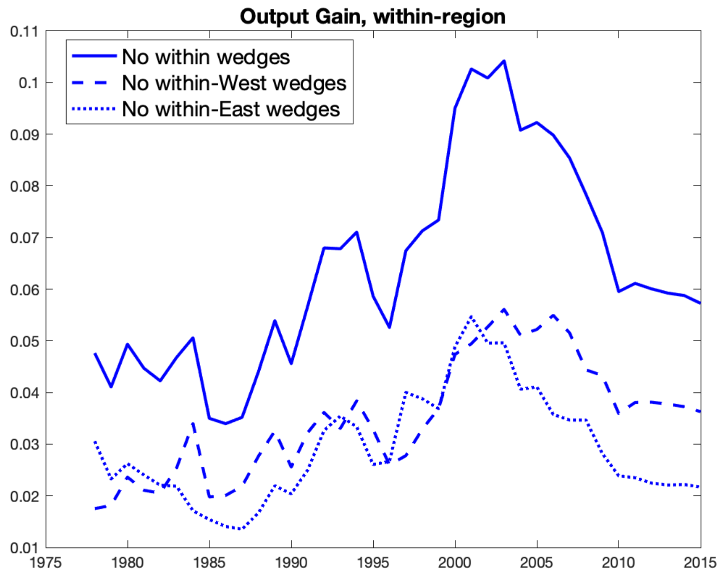
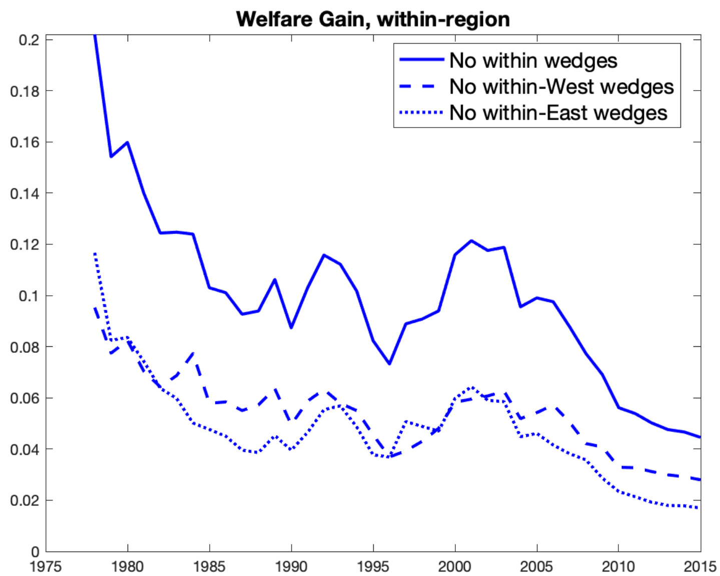


Figure 9: Potential Output and Welfare Gains- Within Regions



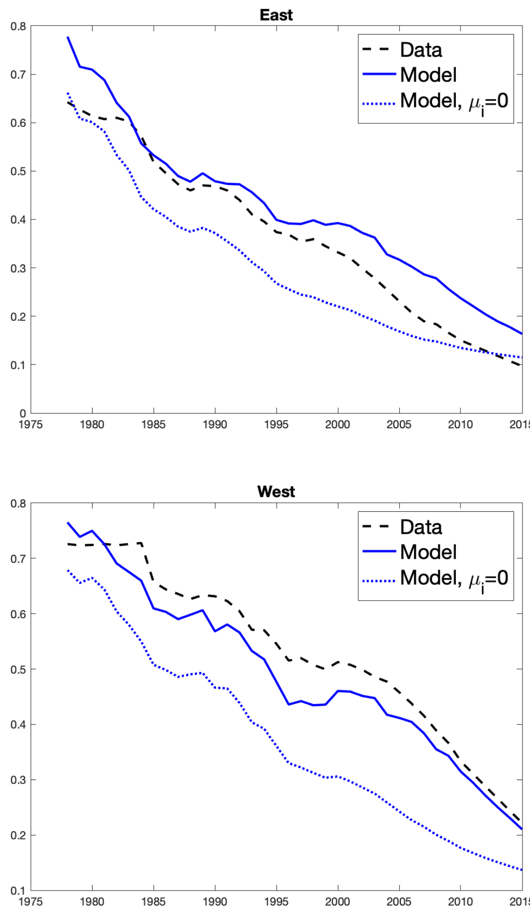


4 Conclusion

Using a unique dataset and a 2-sector 2-region model, I study the output and welfare gain from reallocating labor between sectors and regions in post-reform China. I measure the size of the migration barrier within the Eastern and Western regions between the agricultural and nonagricultural sectors, as well as the migration barrier between the two regions. With a model designed for the regional and sectoral labor reallocation, I quantify the impact of forgone migration on the economy and the potential gains from eliminating the remaining migration barriers. My results suggest that migration has contributed to 34% of output in 2015. Moreover, the output and welfare gains from removing remaining migration barriers can be as large as 25% in 2015.

Appendix

Figure 10: Calibration: Agricultural Employment Share



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