Trade Liberalization, Internal Migration and Regional Income Differences: Evidence from China

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Abstract

International trade and the internal movement of goods and people are closely related. China – increasingly open and with massive internal migration flows – provides an ideal setting to study these interrelationships. We develop a general equilibrium model of internal and external trade with migration, featuring both trade and migration frictions. Using unique province-level data on internal and external trade, and recent micro-census data on internal migration, we estimate international and internal trade costs and internal migration costs. We find all these costs declined substantially after China joined the WTO. We use the model to quantify and decompose the effects of liberalizing trade (international and internal) and relaxing internal migration restrictions on China's aggregate welfare, internal migration, and regional income differences. We find tha external trade liberalization has a large impact on China's trade to GDP ratio, but modestly increases aggregate welfare while increasing regional income differences. In contrast, reducing internal trade costs generates larger welfare gains and reduces regional income differences. While both increase migration flows, migration cost reductions are substantially more important for migration. More surprisingly, lower migration costs only modestly increase aggregate welfare, but substantially decreases regional income differences. Our results suggest that internal market liberalization is much more important than the external trade liberalization as a source of China's post-WTO improvement in aggregate welfare and reduction in regional income inequality.

JEL Classification: F1, F4, R1, O4

Keywords: *Migration; internal trade; gains from trade; China*

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1 Introduction

In the past decade, China has become increasingly integrated into the global economy and has experienced the largest internal migration in human history. Since its accession to the WTO, China's trade to GDP ratio more than doubled from 20% in 2001 to 44% in 2011, with only a slight decline during the financial crisis. Internal migration flows also increased over this period. We present evidence that suggests nearly 118 million people switched counties between 2000 and 2005, and over 40 million switched provinces. This figure is up from 70 million switches between 1995 and 2000, 37 million of whom switched provinces. The internal movement of goods is also large and should not be neglected – in 2002, total inter-provincial flows exceeded international flows by over 13%. If internal trade and migration respond to (and facilitate) international trade, they may also be important determinants of (and transmission mechanisms for) the aggregate gains from trade.

The broad link between international trade and inter-provincial migration and trade is not surprising. Perhaps the most well known example in China of coastal manufacturing expansion with migrant workers is the case of Hon Hai Precision Industry (Foxconn). The rapid increase of Foxconn's workforce to assemble popular Apple products is predominantly due recruitment of migrant workers. At the company's facilities in Shenzhen, for example, which assemble iPhones and iPods at the Guanlan factory and iPads and Macs at the Longhua factory, migrant workers account for slightly over 99% of total employment.[1] This pattern is by no means unique to Foxconn. Just north of Shenzhen, the city of Dongguan exemplifies China's changing economic environment. The city's total trade (imports plus exports) is nearly five times GDP and it alone accounts for a substantial fraction of global supply of computer and electronics components. Its expansion began from a population of 400,000 in 1978, largely engaged in farming and fishing, to over seven million in 2005. Of these seven million, over 70% are migrant workers (World Bank, 2009). The link between internal and external trade is equally intuitive, with facilities increasingly being located inland, for example, in the city of

[1]These data on migrant workers by facility are available through the Fair Labor Association, which Apple hired to audit working conditions at Foxconn factories following a string of highly publicized worker suicides.

Chongqing. In this way, inland assembly and internal trade substitutes for coastal migration.

Motivated by these observations, we examine in detail the interrelationships between trade liberalization, internal migration, and internal trade in general and for China's recent experience in particular. To do this, we exploit unique data on the complete matrix of trading relationships between China's provinces and each other and with the world. We link these to recent individual-level census data on internal migration flows. Together these data allow us to explore the consequences for a significant liberalization of China's external trade, through its accession to the WTO. In the next section, we provide estimates that suggest migration was important for coastal manufacturing expansion in China. Industries that expanded employment disproportionately hire migrant workers. Also, industries with the greatest reduction in tariffs levied on their exports by countries abroad (post-WTO) also disproportionately hire migrant workers. Additional reforms occurred in this period as well, liberalizing the flow of goods and people between China's provinces. We will examine the relative importance of liberalizations in external goods flows, internal goods flows, and internal migration flows for welfare, income differences, and migration flows.

With our detailed internal trade data, along with province-level data on gross output, we estimate internal and external trade costs. Our approach provides an estimate of average trade costs with very little structure. Specifically, we follow Novy (2013)'s generalization of the Head and Ries (2001) measure of trade cost. This measure applies to a broad class of trade models, from Eaton and Kortum (2002) to Melitz (2003), and applies to the model structure we develop in this paper as well. We find substantial regional variation in trade costs in 2002. Trade costs for coastal provinces in the South, for example, are less than half the costs faced by provinces in the central region of China. We find regions to which migrants flow are regions with lower trade costs. This approach also allows us to measure the change in trade costs through time. While informative, we cannot quantitatively examine the effect of these costs, or changes in these costs, on welfare or migration. We are also unable to measure migration costs with just this data alone. Additional structure is required.

To that end, we develop a general equilibrium model of internal and external trade with costly regional migration. At its core, the model is similar to Redding (2012), who extend Eaton and Kortum (2002) to include within-country trade and migration flows. Our key departure is to incorporate inter-provincial migration frictions, which better reflects the unique *Hukou* system of household registration in China. Specifically, we model regional labour mobility as Artuc, Chaudhuri and McLaren (2010) model occupational mobility. Workers differ in their taste for each region. Given a common migration cost, only some fraction of workers choose to move from one region to another in response to a given income differential between the regions. The main mechanisms in the model are straightforward. Reductions in international trade costs affect some regions more than others, depending on their propensity to engage in international trade. Labour responds to changes in a region's real income, which depend positively on nominal wages (which increase if demand for a region's exports increase) and negatively on consumer prices (which decline if imports become cheaper) and housing prices (which increase with a region's population).

We fit this model to key features of China, which is disaggregated into 30 individual provinces (we exclude Tibet for data availability reasons) and the rest of the world captured as a single external entity. Unique to our approach is the use of China's expanded input-output tables. The model calibration crucially depends on data for the full bilateral trading matrix between all provinces with each other and the world. This data has been exploited in other research, notably Poncet (2005) to estimate internal trade costs, but not to examine the relationship between trade liberalization and internal migration flows. Migration data is compiled using the micro-data from China's Population Census 2000 and 2005. Finally, we exploit price level differences between provinces to estimate real income differences from nominal GDP data by province. With the model, we estimate migration costs (see section 3.5 for details) of 1.5 times annual income in the 1995-2000 period. Between 2000 and 2005, however, we find these costs decline to an average of 1.3 times annual income.

With the calibrated model in hand, we simulate its response to various counterfactuals. First, we estimate the overall reduction in international trade costs post-WTO to be approximately twenty percentage points, though this varies across regions. Simulating the measured reduction in international trade costs, we find approximately 2.5 million migrants move towards coastal provinces. Lower internal trade costs result in a similar level of migration. Lower internal *and* external trade (together) leads nearly 5 million workers to switch provinces, aggregate welfare to increase nearly 14%, and regional income differences to decline by over 5%. Relative to the actual level of migration observed between 2002 and 2005, trade costs reductions alone cannot account for the observed migration. Simulating lower migration costs, we find 10.7 million workers moved provinces. Aggregate welfare increases in response by only 1%. Lowering both trade and migration costs together reveals an important complementarity between worker and goods mobility frictions. Specifically, lowering all of these costs together increases welfare by 15.2%, results in 18 million migrants (accounting almost completely for the migration data), and lowers regional income differences by 12.5%.

We contributed to a recently growing literature linking international trade flows with the spatial distribution of labour within countries. Redding (2012), in particular, expands the Eaton-Kortum trade model to incorporate within-country regions between which labour can flow. He demonstrates that the welfare gains from trade depend not only on a region's home-bias but also on changes in the distribution of workers. Cosar and Fajgelbaum (2012) focus on firm, instead of worker, location decisions to link international liberalization with increased concentration of economic activity in areas with good market access. We build on the insights of these theoretical papers to examine the effect of China's external trade liberalization on its massive internal labour flows. Uniquely, we incorporate migration frictions in the model to reflect often explicit restrictions on inter-provincial migration in China.

Our work is also related to empirical investigations of trade's effect on internal migration for other countries. McCaig and Pavcnik (2012) examine the 2001 US-Vietnam Bilateral Trade Agreement and document substantial worker flows towards internationally integrated industries and provinces, especially for younger workers. Research with individual Brazilian data establishes a positive relationship between internal migration flows and employment at foreign owned exporting establishments (Aguayo-Tellez and Muendler, 2009) and measures of a region's market access (Hering and Paillacar, 2012). There is also a large urban-economics literature investigating the role of international trade for altering the spatial distribution of firms and factors within a country (see, for example, Hanson, 1998). Little work has been done, however, investigating the case of China – perhaps the largest and fastest expansion of trade and internal migration ever recorded. Existing work for China typically abstracts from general equilibrium effects and investigates data only prior to 2000 (see, for example, Lin, Wang and Zhao, 2004 or Poncet, 2006). Our focus will be on developing a full general equilibrium model to quantitatively examine China's recent trade and migration patterns.

Our paper proceeds as follows. Section 2 documents China's internal migration flows, focusing on inter-provincial flows for economic reasons. This section also documents key internal trade relationships and regional differences in international trade exposure. Section 3 outlines and calibrates a modified Eaton-Kortum trade model, based on Redding (2012), that we use in Section 4 to explore various counterfactual experiments relating international trade costs, internal migration frictions, internal trade flows, and inter-provincial migration in China. Section 5 concludes.

2 China's Internal Migration and Trade

In this section, we briefly outline key features of the data on China's internal migration and trade.

2.1 Internal Migration

Migration data is inferred from responses provided to the Census of China 2005. We define a migrant here as an individual who lived in another province five years ago that moved for work-related reasons. Overall, between 2000 and 2005, there were 24.8 million inter-provincial migrants for work reasons. These were heavily directed towards coastal provinces and away from interior ones. Given the later focus on trade liberalization and China's joining of the WTO, consider the period 2002-2005. In this time period, there were 22.2 million cross border migrants for work. With the source and destination province recorded in the census, we calculate net-migration by province as a fraction of 2005 employment in each province. This is reported in Table 6.

Migrants do not randomly sort across industries, but are predominately concentrated among manufacturing and construction enterprises in eastern provinces. It is not a trivial exercise to reconcile the different industrial classification schemes used in the 2000 and 2005 census, as the industrial classification codes were extensively updated in 2002, the distribution of employment across industries and years is provided in Table 7. The percentage change is listed in the last column. By far, the largest increases were experienced in the health, education, social services, and transport and trade sectors. Manufacturing and construction, as well as raw material production/mining, also saw large increases.

These changes can be decomposed by region, and is displayed in Table 8. The total change in employment, by region and industry, can be compared to the total inter-provincial migrant flow. Table 9 displays this breakdown and the contribution of migrants to overall industry employment growth by region. Eastern manufacturing - by far the largest industry of employment for migrants (and also a tradable sector) - displays an interesting result. *There were more migrants flowing into this industry than there was overall employment growth.* That is, migration seems to have displaced domestic workers in this industry. While suggestive, it appears that migrants are disproportionately flowing towards regions and industries that are more heavily oriented towards trade.

Census data from 2005 can also be used to illustrate these patterns. It is clear in the data that migrants account for a larger share of employment in provinces and industries that export more abroad. We illustrate this pattern in Figure 1. Panel a displays the strong propensity of migrants to move towards provinces that export more abroad, with Shanghai, Guangdong, Tianjin, Zhejian, and Beijing among the top destinations. Panel b displays a similarly strong propensity of migrants to seek employment within industries that export more abroad. This patterns is also true within provinces. Indeed, a regression at the industry-province level of migrants on industry exports (both in logs), controlling for industry employment and a set of province fixed-effects, reveals a strong positive coefficient on exports of 0.07. That is, a 10% increase in exports of an industry in a given province, holding total employment constant, will result in a 0.7% increase in migrants employed.

Moving beyond export volumes, we can also link changes in global trade policy towards China to migration patterns across industries. We collect tariff data from TRAINS applied to China's exports by the rest of the world in 2005 and 2000. The change in tariff rates reflects China's ability to increase exports. To measure tariffs against China at the industry level, we take the simple average of effective applied rates across product lines within ISIC Revision 3 categories and aggregate to GB2002 with import volume weights. We plot the change between 2005 and 2000 against each industry's migrant share of employment in panel c of Figure 1. The negative relationship suggests industries that the rest of the world liberalized to a greater extent are industries that disproportionately employ migrant workers. The strength of this relationship is especially high when industries 15 (drinking products), 25-28 (crude oil, fuel, and chemicals), and 45 (local gas supply) are excluded, as these industries are concentrated in the lower-right of the Figure.

The previous industry-level patterns only exploited total international exports. For a subset of industries, we can examine the relationship between migration and an industry's export orientation independent of volume as measured by the ratio of exports to gross-output. To do this, we use manufacturing data on production and trade from CEPII, by three-digit ISIC industries. In Figure 2 we display each manufacturing sector's export share of total output in 2000 against two measures. First, in panel a, we display the positive relationship between export orientation and employment growth to 2003 (the latest year where production data for China exists in the CEPII data). So, sectors that export more are sectors that grew. Second, in panel b, we display the positive relationship between export orientation and migrant's share of each sector's total employment. So, sectors that export more are sectors that disproportionately employ inter-provincial migrants.

The key motivation for regional migration, from a typical worker's perspective, is to improve their living standard. There are stark differences in real income levels across regions. If we measure real income as nominal GDP per worker (from official provincial accounts) deflated by the price of a common basket of consumer goods by province, we can get a sense of the magnitude of these living standard differences. We provide the relative real income calculated in this way for 2002 in Table 6. Large real income differences exist, possibly suggesting large costs of moving between regions, consistent with China's *Hukou* household registration system having binding for many workers. We will return to the issue of migration frictions later in the paper. For now, let us move to a more detailed examination of China's internal and external trade patterns.

2.1.1 Characteristics of Inter-Provincial Migrants

The strong link suggested above between expanding employment opportunities in export oriented industries and provinces is not surprising given the migrants' characteristics. The census directly asks respondents who left their original *Hukou* registration place the reason for migrating. Table 1 displays key characteristics of inter-provincial migrants in China. Those individuals who are living in a province other than their original registration place number 165 million, 45% of whom moved for work reasons. Restricting to those migrants who are employed, and who moved within the previous five years, lowers the number to nearly 31 million where over 93% say they moved for work. Other characteristics show that recent migrants are disproportionately those without children, coming from agricultural origins (as indicated by their registration type), working at private companies, and are roughly equally mixed between genders.

2.2 China's Intra- and Inter-National Trade

We extract province-level trade data, both between province pairs and internationally, from various regional input-output tables. The 2002 tables report total imports and exports for each provinces to the rest of China (aggregated) and with the world. It further reports (importantly) the entire internal bilateral trade matrix for every possible pair of provinces. The 2007 tables report the same but for a restricted set of eight regions of China.[2]

[2] The eight regions are classified as: Northeast (Heilongjiang, Jilin, Liaoning), North Municipalities (Beijing, Tianjin), North Coast (Hebei, Shandong), Central Coast (Jiangsu, Shanghai, Zhejiang), South Coast (Fujian, Guangdong, Hainan), Central (Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi), Northwest (Inner Mongolia, Shaanxi, Ningxia, Gansu, Qinghai, Xinjiang), and Southwest (Sichuan, Chongqing, Yunnan, Guizhou, Guanxi, Tibet).

Table 1: Migrant Characteristics (from Census 2000)

	All Migrants	Employed Migrants	Employed Migrants, 2000-2005
Number	165.4 M	98.8 M	30.6 M
Reason for Migrating			
Work	45.4%	70.7%	93.4%
Family	30.5%	15.0%	4.1%
Education	6.1%	0.5%	2.2%
Other	17.0%	13.9%	0.2%
Other Characteristics			
With Children	30%	30%	25%
Agricultural Hukou	62%	67%	87%
Male	51%	57%	56%
Private/Other Company	22%	37%	57%

Notes: Characteristics of interprovincial migrants from the 2005 census. Migrants are defined as individuals living in a province other than their *Hukou* registration province. "Private/other" company refers to employment at a private or other company – not at state, collective, or other enterprise and not self-employed.

We report the bilateral trade between the eight regions and each other, and the rest of the world, for 2002 and 2007 in Table 2. Specifically, total import flows are expressed relative to each importing region's total domestic absorption. Absorption is defined as usual: total gross output of a region less exports to other regions plus imports from other regions. Each row should sum to one across columns. One difficulty in constructing these measures is in determine absorption for the rest of the world. To do this, we take non-China nominal GDP, measured in yuan, from the Penn World Table version 7. We assume the intermediate input share of output is 0.5 for the world, which implies global output is double value-added. Based on this, we estimate global output as 695.52 trillion yuan in 2002. Combined with trade data from the Input-Output tables, we estimate global absorption as 694.89 trillion yuan. We repeat this for 2007 and find absorption of 926.38 trillion yuan. We explore the sensitivity of our main results to alternative assumptions of the intermediate input share for the world.

Some regions import substantially more from the rest of the world than they do from the other regions of China. Consider the South Coastal region, where many the Foxconn facilities discussed previously are located. This region imports nearly three times as much from abroad than it does from other regions within China. This region also exports more than the rest of China (excluding the Central coastal region, which includes Shanghai) combined. These values will play a direct role in Section **??** to estimate trade costs between regions.

The diagonal elements of the each matrix provide a measure of a region's home-bias. This measure the fraction of total expenditures allocated to goods and services produced within the region. Put another way, if π_{ij} is the fraction of expenditures by region i allocated to goods and services from region j, then the home-bias is $\pi_{ii} = 1 - \sum_{j=1}^{N} \pi_{ij}$.[3] Interior regions of China have much higher home-bias than coastal regions. We estimate the value for the central region at 0.911 compared to only 0.76 for the south coast and 0.75 for the northern municipalities of Beijing and Tianjin.

At the province level, we can estimate all of these values for 2002. We do not report the entire matrix of trading relationships, but do provide some key measures for each province in Table 6. Notably, and consistent with the regional data, interior provinces have higher home-bias than coastal provinces. In the second column of the same table, we report the ratio of total international exports to total gross output by province. Again, coastal regions have significantly greater fraction of production oriented towards international exports. These suggest international trade liberalization will disproportionately benefit these regions, leading to increased labour demand and consequently increased migration towards the coast. Moreover, trade liberalization will lower the overall price of consumer goods by more in coastal regions, increasing real income levels and further driving migration flows. The model will quantify the extent to which this intuition holds.

2.2.1 Estimates of Internal and External Trade Costs

Conveniently, there are recently developed methods to estimate trade costs from observable trade flows relative to production consumed domestically. The approach

[3] This measure can also be estimated from data on gross output and trade flows by province as $\pi_{ii} = [1 + m_i/(y_i - x_i)]^{-1}$, where m_i is province i's total imports, y_i is its total gross output, and x_i is its total exports.

Table 2: Bilateral Import to Domestic Absorption Ratios, by Region

(a) Year 2002

	Source Region								
Importer	Northeast	Beijing/Tianjin	North coast	Central coast	South coast	Central region	Northwest	Southwest	Abroad
Northeast	0.9058	0.0050	0.0078	0.0061	0.0110	0.0086	0.0057	0.0058	0.0443
Beijing/Tianjin	0.0261	0.7506	0.0637	0.0184	0.0177	0.0222	0.0075	0.0065	0.0874
North coast	0.0132	0.0161	0.8713	0.0196	0.0115	0.0276	0.0060	0.0048	0.0298
Central coast	0.0021	0.0013	0.0047	0.8477	0.0122	0.0181	0.0039	0.0033	0.1068
South coast	0.0038	0.0033	0.0043	0.0193	0.7605	0.0159	0.0031	0.0121	0.1775
Central region	0.0042	0.0014	0.0080	0.0365	0.0155	0.9110	0.0047	0.0043	0.0143
Northwest	0.0132	0.0040	0.0151	0.0200	0.0310	0.0246	0.8474	0.0235	0.0213
Southwest	0.0058	0.0014	0.0028	0.0106	0.0284	0.0098	0.0053	0.9215	0.0145
Abroad	0.0002	0.0003	0.0003	0.0013	0.0017	0.0001	0.0001	0.0001	0.9960

(b) Year 2007

	Source Region								
Importer	Northeast	Beijing/Tianjin	North coast	Central coast	South coast	Central region	Northwest	Southwest	Abroad
Northeast	0.8451	0.0106	0.0162	0.0054	0.0202	0.0074	0.0098	0.0050	0.0803
Beijing/Tianjin	0.0274	0.6966	0.0860	0.0115	0.0210	0.0139	0.0143	0.0038	0.1257
North coast	0.0157	0.0284	0.8366	0.0103	0.0141	0.0308	0.0147	0.0057	0.0438
Central coast	0.0097	0.0053	0.0129	0.7918	0.0169	0.0409	0.0145	0.0079	0.1001
South coast	0.0108	0.0045	0.0129	0.0374	0.7420	0.0292	0.0134	0.0217	0.1280
Central region	0.0106	0.0047	0.0272	0.0293	0.0245	0.8407	0.0149	0.0076	0.0405
Northwest	0.0144	0.0114	0.0369	0.0161	0.0393	0.0264	0.7779	0.0177	0.0599
Southwest	0.0100	0.0032	0.0087	0.0081	0.0502	0.0116	0.0161	0.8484	0.0436
Abroad	0.0004	0.0007	0.0008	0.0037	0.0024	0.0003	0.0004	0.0002	0.9912

Note: Displays the ratio of the total imports by each region, from each other region, relative to the importing region's domestic absorption. Absorption is the total gross output of a region less exports to other regions and abroad plus imports from other regions and abroad.

we use originated with Head and Ries (2001) and was later expanded by Novy (2013). For a broad class of trade models, the (geometric) average of trade costs between region i and region j (relative to internal trade costs) will equal

$$\tau_{ij} = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{1/2\theta} - 1,$$

where x_{ii} is expenditures on locally produced goods and services, x_{ij} is the expenditures from region i on region j goods and services, and θ is a parameter governing the elasticity of trade flows with respect to trade costs. This expression can be equally well evaluated using trade share data, such as those in Table 2, as $\tau_{ij} = (\pi_{ii}\pi_{jj}/\pi_{ij}\pi_{ji})^{1/2\theta} - 1$. We set the elasticity parameter to 4, in line with recent results by Simonovska and Waugh (2011), and leave a full discussion of this parameter to the model calibration in Section 3.6.

Using the same regional trade share data of the previous section, we estimate internal and external trade costs between each of China's regions with each other and the rest of the world. We present these estimates in Table 3. Some notable patterns reveal themselves. Trade costs between the South Coastal region and the rest of the world on approximately 150% in both 2002 and 2007, in contrast to the other regions of China that sees a drop in trade costs. This is plausible, given the special status provinces such as Guangdong, and others in this region, received even by 2002. Costs for this region to trade with other regions of China were, in 2002, often higher than this region's international trade costs. Trade between the South Coast and the more northern regions were all in excess of 150%. The Central Region had the largest international trade costs in 2002, exceeding 370%. This region also saw one of the largest reductions in costs, falling to 270% by 2007.

Quantitatively evaluating the effect of these changes in internal trade costs is still a work in progress. For the remainder of the paper, we focus on reductions in international trade costs, and the role of migration and internal trade for the magnitude of the overall gains from trade. To that end, we turn now to a model capable of shedding light on these issues.

Table 3: Bilateral Trade Costs, by Region

(a) Year 2002

	Source Region								
Importer	Northeast	Beijing/Tianjin	North coast	Central coast	South coast	Central region	Northwest	Southwest	Abroad
Northeast		145.2	163.6	248.8	193.4	201.9	166.2	204.4	294.9
Beijing/Tianjin	145.2		87.7	206.9	166.7	191.4	184.1	239.6	230.4
North coast	163.6	87.7		169.8	185.0	138.6	158.0	238.5	286.9
Central coast	248.8	206.9	169.8		138.6	111.7	167.9	205.6	181.7
South coast	193.4	166.7	185.0	138.6		134.1	154.5	124.6	150.5
Central region	201.9	191.4	138.6	111.7	134.1		151.3	194.9	372.8
Northwest	166.2	184.1	158.0	167.9	154.5	151.3		148.9	383.9
Southwest	204.4	239.6	238.5	205.6	124.6	194.9	148.9		396.6
Abroad	294.9	230.4	286.9	181.7	150.5	372.8	383.9	396.6	

(b) Year 2007

	Source Region								
Importer	Northeast	Beijing/Tianjin	North coast	Central coast	South coast	Central region	Northwest	Southwest	Abroad
Northeast		127.2	140.9	193.3	141.2	174.3	152.0	187.6	237.4
Beijing/Tianjin	127.2		74.9	176.7	157.5	169.9	138.7	231.4	185.1
North coast	140.9	74.9		162.1	147.8	104.8	114.1	189.5	235.5
Central coast	193.3	176.7	162.1		111.6	95.4	137.5	180.0	148.5
South coast	141.2	157.5	147.8	111.6		105.2	111.2	93.5	150.8
Central region	174.3	169.9	104.8	95.4	105.2		118.9	165.1	270.1
Northwest	152.0	138.7	114.1	137.5	111.2	118.9		126.6	245.6
Southwest	187.6	231.4	189.5	180.0	93.5	165.1	126.6		291.7
Abroad	237.4	185.1	235.5	148.5	150.8	270.1	245.6	291.7	

Note: Displays the trade costs estimates using the Novy (2013) approach for each of China's regions between each other and the rest of the world. The values are in tariff-equivalent percentages and reflect the geometric average of the trade costs between each pair. We assume an elasticity of trade with respect to costs of 4, following Simonovska and Waugh (2011).

3 Quantitative Model

In this section, we provide a brief sketch of the model used for the analysis. Overall, the model is only a slight departure from Redding (2012) in that we incorporate between-province migration frictions. These frictions prevent equalization of real incomes across space, which is clearly evident in the data.

3.1 The Trade Structure

There are $N+1$ regions representing China's provinces plus the rest of the world. Households in each region n derive utility from consuming a final good and residential housing (denoted H_{Un}) using

$$U_{in} = C_n^{\alpha} H_{Un}^{1-\alpha}.$$

Final goods are produced by a perfectly competitive aggregator firm using a CES technology given by

$$Y_n = \left(\int_0^1 y_n(j)^{(\sigma-1)/\sigma} dj \right)^{\sigma/(\sigma-1)},$$

where σ is the (constant) elasticity of substitution between intermediate goods j. Intermediates $y_n(j)$ may be sourced from local producers or imported.

Production of individual intermediate goods j is undertaken by firms in perfect competition that use labour, intermediate inputs, and land with the following technology

$$y_n(j) = \varphi_n(j) l_n(j)^{\beta} H_{Yn}(j)^{\eta} q_n(j)^{1-\beta-\eta},$$

where $\varphi_n(j)$ is the firm's TFP, $l_n(j)$ is labour, $H_{Yn}(j)$ is land inputs, and $q_n(j)$ is intermediate input. This intermediate input comes from the total final goods available in region n; that is, $Y_n = C_n + q$, where q is the total intermediates demanded by firms producing in region n. Productivity differs across all firms and is modeled probabilistically, following Eaton and Kortum (2002), where for each region φ is distributed according to a Frechet distribution

$$F_i(\varphi) = e^{-T_i \varphi^{-\theta}},$$

with dispersion parameter θ and location parameter T_i. Productivity differences across goods j decrease in θ and increase in T_i.

A firm with productivity φ in region i would charge a purchaser in region n

$$p_{ni}(j) = \frac{\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta}}{\varphi},$$

where $\tau_{ni} \geq 1$ is an iceberg trade cost, w_i are wages in region i, r_i is the price of land, and P_i is their aggregate price index.

Given this structure, purchasers in each region opt to source intermediates $y_n(j)$ from the lowest cost location. This results in expenditures being allocated across regions according to each region's technology, input costs, and trade costs. Denote π_{ni} the fraction of region n spending allocated to goods produced in region i. Given the Frechet distribution of technology,

$$\pi_{ni} = \frac{T_i \left(\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta} \right)^{-\theta}}{\sum_{k=1}^{N+1} T_k \left(\tau_{nk} w_k^{\beta} r_k^{\eta} P_k^{1-\beta-\eta} \right)^{-\theta}}, \tag{1}$$

which results in an aggregate price index of

$$P_n = \gamma \left[\sum_{i=1}^{N+1} T_i \left(\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta} \right)^{-\theta} \right]^{-1/\theta}, \tag{2}$$

where $\gamma = \Gamma\left(1 + \frac{1-\sigma}{\theta}\right)^{1/(1-\sigma)}$. It will prove convenient to express this price as $P_n = (\pi_{nn}/\gamma T_n)^{1/\theta} w_n^{\beta} r_n^{\eta} P_n^{1-\beta-\eta}$, where we assume $\tau_{nn} = 1$. This can be further simplified to $P_n = (\pi_{nn}/\gamma T_n)^{\frac{1}{\theta(\beta+\eta)}} w_n^{\frac{\beta}{\beta+\eta}} r_n^{\frac{\eta}{\beta+\eta}}$.

3.2 Internal Labour Migration

We model migration decisions of agents as resulting from real income differences between regions, a region-specific taste shock that varies across agents, and migration costs between regions. Specifically, worker l who was born in region i draws, upon birth, a valuation $\varepsilon_j(l)$ for all regions $j \in \{1, N\}$. Interpret this as a taste parameter over all possible provinces of China. Let these preferences draws be i.i.d. across workers and $F(.)$ and $f(.)$ are the CDF and PDF of the distribution across individuals. Workers are homogeneous except for differences in location-specific tastes. This approach closely follows the occupational mobility research, and Artuc, Chaudhuri and McLaren (2010) in particular.

Migrating out out of one's birth region results in a migration cost C_{ij} each period, where $C_{ii} = 0$ for all i. Migration also involves a benefit. Regions differ in their real income levels, which we denote as V_i. If the worker decides to stay in her region of birth i, then welfare is $V_i + \varepsilon_i(l)$. If the worker decides to move to region j, welfare is $V_j + \varepsilon_j(l) - C_{ij}$. So, a worker from region i will migrate to region j if and only if

$$V_j + \varepsilon_j(l) - C_{ij} > V_k + \varepsilon_k(l) - C_{ik}, \;\; k \neq j.$$

The proportion of region i workers who migrate to region j is then

$$m_{ij} \;\; = \;\; Pr\left\{V_j + \varepsilon_j - C_{ij} \geq \max_{k \neq j} \{V_k + \varepsilon_k - C_{ik}\}\right\}.$$

For a particular distribution of tastes, this proportion can be solved explicitly. Assume that the amenity value ε_i is drawn from a Gumbel distribution:

$$F(\varepsilon) = e^{-e^{-\frac{\varepsilon}{\kappa} - \gamma}},$$

where γ is the Euler–Mascheroni constant that centers the distribution over zero. The first and second moments are $E[\varepsilon] = 0$ and $Var[\varepsilon] = \frac{\pi^2 \kappa^2}{6}$. The usefulness of this particular distribution is demonstrated in the following proposition.

Proposition 1 *Given real incomes for each region V_i, migration costs between all regional pairs C_{ij}, and heterogeneous tastes over regions that follow $F(\varepsilon)$, the share* *of region i workers that migrate to region j is*

$$m_{ij} = \frac{e^{\left(V_j - V_i - C_{ij}\right)/\kappa}}{\sum_{k=1}^{N} e^{\left(V_k - V_i - C_{ik}\right)/\kappa}}. \tag{3}$$

Proof: See appendix.

Migration between two regions is increasing in the gap between the destination and origin regions and decreasing in the migration costs between the regions. The variance of taste parameter κ (inversely) determines the elasticity of migration with respect to income differences net of migration costs. We will estimate this parameter empirically later on. Let us now proceed to how real income levels are determined in the model.

Given migration shares from equation 3, the number of workers in each region can be determined conditional on the (exogenous) initial distribution of workers across birth (Hukou) regions. Define the number of workers registered in region i as L_i^0. The employment in each region i is

$$L_i = \sum_{j=1}^{N} m_{ji} L_j^0. \tag{4}$$

We conclude this section by highlighting a key detail in how we model migration. We measure flows relative to individual's original *Hukou* registration province. This presumes that migration costs C_{ij} are defined for an individual with *Hukou* registration in province i that moves into province j. The costs do not change for this individual after the move – migration decisions are always taken relative to the original *Hukou* registration province not the current province of residence. This implies (1) it is costless for migrants to return to their *Hukou* province and (2) costs of living outside of the *Hukou* province are perpetually incurred (not once and for all upon migration).

3.3 Real Income

Households in each region are populated by L_n agents, who supply labour inelastically and are the equal recipients of all income generated in that region. Total income in region n is then given by

$$v_n L_n = w_n L_n + (1-\alpha) v_n L_n + \eta R_n,$$

where R_n is total revenue from all producing firms in region n. In this expression, v_n denotes per-capita income derived from labour income and household and firms' spending on land. The expression can be further simplified given the Cobb-Douglas nature of the production technology, which implies a constant fraction β of revenue is spent on labour inputs. Through some additional rearrangement, nominal income in region n is

$$v_n = \left(\frac{\beta+\eta}{\alpha\beta}\right) w_n,$$

and real income is

$$V_n = \frac{v_n}{P_n^{\alpha} r_n^{1-\alpha}}. \tag{5}$$

To solve for the cost-of-living in region n, and therefore the real income expression, note that land market clearing implies

$$r_n = \left(\frac{(1-\alpha)\beta+\eta}{\alpha\beta}\right) \frac{w_n L_n}{H_n}, \tag{6}$$

where $H_n = H_{Un} + H_{Yn}$ is the total stock of land in region n. With this expression, and the expression for the goods price index,

$$V_n \propto (T_n/\pi_{nn})^{\frac{\alpha}{\theta(\beta+\eta)}} h_n^{\frac{\eta+(1-\alpha)\beta}{\beta+\eta}},$$

where h_n denotes land per capita and the proportionality constant is common across all $N+1$ regions.

3.4 Equilibrium System

The model can be solved two ways. One option would be to match observed trade shares by choice of regional productivity and trade costs parameters. Equilibrium prices and allocations would be solve by imposing trade balance conditions between provinces and from there backing out other variables of interest. Another option, which will be the main focus here, is to express changes in the model equilibrium as a function of changes in underlying parameters of interest. This avoids the issue of actually estimating the level of trade costs or productivity. It is a method successfully employed in another context recently by Caliendo and Parro (2012).

Denote $\hat{x} = x'/x$, where x' is the counterfactual value of x. The following system of equations solves for changes in prices ($\hat{P}_n$), wages ($\hat{w}_n$), regional employment ($\hat{L}_n$) and trade flows ($\hat{\pi}_{ni}$) as a function of changes in trade costs ($\hat{d}_{ni}$) and changes in migration costs ($\hat{C}_{in}$):

$$\hat{w}_n \hat{L}_n Y_n = \sum_{i=1}^{N+1} \pi'_{in} \hat{w}_i \hat{L}_i Y_i, \tag{7}$$

$$\pi'_{ni} = \frac{\pi_{ni}\left(\hat{\tau}_{ni}\hat{w}_i^{\beta+\eta}\hat{P}_i^{1-\beta-\eta}\hat{L}_i^{\eta}\right)^{-\theta}}{\sum_{k=1}^{N+1}\pi_{nk}\left(\hat{\tau}_{nk}\hat{w}_k^{\beta+\eta}\hat{P}_k^{1-\beta-\eta}\hat{L}_k^{\eta}\right)^{-\theta}}, \tag{8}$$

$$\hat{P}_n = \left[\sum_{k=1}^{N+1}\pi_{nk}\left(\hat{\tau}_{nk}\hat{w}_k^{\beta+\eta}\hat{P}_k^{1-\beta-\eta}\hat{L}_k^{\eta}\right)^{-\theta}\right]^{-1/\theta}, \tag{9}$$

$$\hat{V}_n = \frac{\hat{w}_n^{\alpha}}{\hat{P}_n^{\alpha}\hat{L}_n^{1-\alpha}}, \tag{10}$$

$$L'_n = \sum_{i=1}^{N}\left[\left(\frac{e^{\left(V'_n - V'_i - C'_{in}\right)/\kappa}}{\sum_{k=1}^{N} e^{\left(V'_k - V'_i - C'_{ik}\right)/\kappa}}\right)L_i^0\right]. \tag{11}$$

A few important points about the above system is in order. First, note that employment only changes for regions within China. The trade shares, prices, and wages are determined by the interaction of all regions both within China and abroad. The key departure from (Redding, 2012) is the migration frictions captured by equation 11.

3.5 Changes in Aggregate Outcomes

We measure change in three key aggregate outcomes: average real income, real GDP, and welfare. The first measure captures average real income, without accounting for migration costs or non-pecuniary benefits of living in any given region.

The second measure is the change in GDP measured with initial prices. The final measure represents the change in aggregate welfare. We derive in the following three subsections.

3.5.1 Average Real Income

Aggregate real income is a population-weighted across each province's: $V = \sum_{n=1}^{N} V_n \lambda_n$, where $\lambda_n = L_n / \sum_{i=1}^{N} L_i$. The difficulty is that when the model is solved in terms of equilibrium *changes*, the level of income in each province V_n is not known; only $\hat{V}_n$ is known. However, since initial real incomes are known from data (see calibration section), aggregate welfare is $V = \sum_{n=1}^{N} \mu_n \lambda_n$, where μ_n denotes initial real incomes relative to the national average (from data).

Given this measure of aggregate welfare, denote each province's contribution to the initial income level as $\omega_n = \mu_n \lambda_n / \sum_{n=1}^{N} \mu_n \lambda_n$. It is straightforward to show the aggregate change in real incomes in each counterfactual $\hat{V} \equiv V'/V$ is then

$$\hat{V} = \sum_{n=1}^{N} \omega_n \hat{V}_n \hat{\lambda}_n.$$

3.5.2 Aggregate Real GDP

Initial nominal (and real) GDP is the sum of value added across provinces. Value added includes produced value-added – captured as firms' payments to primary factors, labour and land – and also includes payments to land used as housing (that is, by households not firms). Equivalently, it is payments to labour by firms plus total payments to land by firms and households. So, let G represent GDP,

$$\begin{aligned} G_n &= P_n Y_n (\beta + \eta) + (1 - \alpha) v_n L_n, \\ &= \left(\frac{\beta + \eta}{\alpha \beta} \right) w_n L_n. \end{aligned}$$

Real GDP in the counterfactual equilibrium is calculated in the same way but using initial period prices to value produced value-added and payments to land,

$$G'_n = \frac{P'_n Y'_n(\beta+\eta)}{\hat{P}_n} + \frac{(1-\alpha)v'_n L'_n}{\hat{r}_n}.$$

This can be re-written as

$$\begin{aligned} G'_n &= \frac{\hat{w}_n \hat{\lambda}_n(\beta+\eta)}{\hat{P}_n}\frac{w_n L_n}{\beta} + \frac{(1-\alpha)\hat{w}_n\hat{\lambda}_n}{\hat{r}_n}\left(\frac{\beta+\eta}{\alpha\beta}\right) w_n L_n, \\ &= \left(\frac{\beta+\eta}{\alpha\beta}\right) w_n L_n \left[\frac{\hat{w}_n\hat{\lambda}_n\alpha}{\hat{P}_n} + \frac{(1-\alpha)\hat{w}_n\hat{\lambda}_n}{\hat{r}_n}\right], \\ &= \left(\frac{\beta+\eta}{\alpha\beta}\right) w_n L_n \left[1-\alpha+\alpha\frac{\hat{w}_n\hat{\lambda}_n}{\hat{P}_n}\right], \end{aligned}$$

where the last line follows from $\hat{r}_n = \hat{w}_n\hat{\lambda}_n$. Since $G_n = \left(\frac{\beta+\eta}{\alpha\beta}\right) w_n L_n$ we have

$$\hat{G}_n = 1-\alpha+\alpha\frac{\hat{w}_n\hat{\lambda}_n}{\hat{P}_n}.$$

Aggregating across provinces is straightforward. National initial nominal GDP is $G = \left(\frac{\beta+\eta}{\alpha\beta}\right)\sum_{n=1}^{N} w_n L_n$. Similarly, counterfactual national real GDP is $G' = \sum_{n=1}^{N}\left(\frac{\beta+\eta}{\alpha\beta}\right) w_n L_n \left[1-\alpha+\alpha\frac{\hat{w}_n\hat{\lambda}_n}{\hat{P}_n}\right]$. So, the change in national real GDP is

$$\hat{G} = \sum_{n=1}^{N}\omega_n\left[1-\alpha+\alpha\frac{\hat{w}_n\hat{\lambda}_n}{\hat{P}_n}\right],$$

where (unlike the previous section) the province's initial GDP share are the weights $\omega_n = w_n L_n / \sum_{n=1}^{N} w_n L_n$.

3.5.3 Aggregate Welfare

Aggregate welfare, however, goes beyond changes in real income, as agents derive utility directly from residing in a particular location – through their ε draws – and incur costs when living outside their home (Hukou) region. To measure aggregate welfare in our model requires we exploit a number of useful properties of the

Gumbel distribution.

Imagine first a China where no one can move outside their Hukou region. In our model, this corresponds to a world where m_{ij} is an $N \times N$ identity matrix. Since the taste parameter for each region is distributed with CDF

$$F_{\varepsilon}(x) = e^{-e^{-\frac{x}{\kappa}-\gamma}}$$

(Gumbel with mean zero and parameter κ), the distribution of welfare U_i is also Gumbel with mean V_i and parameter κ. This follows from linear transformations of a Gumbel distributed random variable also being Gumbel distributed with the same linear transformation of the mean. The CDF of U_i is therefore

$$\begin{aligned} F_{U_i}(x) &= e^{-e^{-\frac{x-(V_i-C_{ii})}{\kappa}-\gamma}}, \\ &= exp\left[-exp\left(-\gamma\right) \cdot exp\left(-\frac{x}{\kappa}\right) \cdot exp\left(\frac{V_i - C_{ii}}{\kappa}\right)\right]. \end{aligned}$$

Note that I include C_{ii} despite it equaling zero, as this will prove useful shortly.

With migration, workers with Hukou registration from region i are spread all throughout the country. Their welfare will depend on where they live, which responds to real incomes, migration costs, and (importantly) their individual taste parameter. The welfare of each individual l with Hukou registration in region i is

$$U_i(l) = \max_{j=1,\ldots,N} \left\{V_j - C_{ij} + \varepsilon_j(l)\right\}.$$

Thankfully, Gumbel distributions have a nice property (maximum stability). Since the distribution of $V_j - C_{ij} + \varepsilon_j(l)$ is Gumbel with mean $V_j - C_{ij}$ across all individuals registered in region i, which has a known distribution provided above, we can derive the CDF of U_i in the presence of migration (denoted $G_{U_i}(x)$). Using the definition of $U_i(l)$,

$$\begin{aligned}
G_{U_i}(x) &= \prod_{j=1}^{N} F_{U_i}(x), \\
&= \prod_{j=1}^{N} exp\left[-exp(-\gamma)\cdot exp\left(-\frac{x}{\kappa}\right)\cdot exp\left(\frac{V_j - C_{ij}}{\kappa}\right)\right], \\
&= exp\left[-exp(-\gamma)\cdot exp\left(-\frac{x}{\kappa}\right)\cdot \sum_{j=1}^{N} exp\left(\frac{V_j - C_{ij}}{\kappa}\right)\right].
\end{aligned}$$

This proves the distribution of U_i with migration is also Gumbel with mean $\kappa ln \sum_j e^{\frac{V_j - C_{ij}}{\kappa}}$ and parameter κ. The average welfare of a worker registered in region i is therefore $\kappa ln \sum_j e^{\frac{V_j - C_{ij}}{\kappa}}$.

Aggregate welfare is the mean across all regions of registration, weighted by initial registration population L_o^i. So,

$$W = \sum_{i=1}^{N} \lambda_i^0 \left[\kappa ln \sum_{j=1}^{N} e^{\frac{V_j - C_{ij}}{\kappa}}\right],$$

where λ_i^0 is the fraction of China's population registered in region i.[4] The change in aggregate welfare is simply $\hat{W} = W'/W$, using the above expression before and after a counterfactual experiment.

Before proceeding to these experiments, the model must be calibrated in an empirically reasonable way. It is to the calibration that we now turn.

[4] A region's welfare relates directly to worker migration in the model. To see this clearly, consider the case of zero migration costs ($C_{ij} = 0$ for all i, j). Aggregate welfare is $e^{W/\kappa} = \sum_{j=1}^{N} e^{\frac{V_j}{\kappa}}$. From our earlier migration equation, the share of region i's population that migrats to region j is $m_{ij} = \frac{e^{V_j/\kappa}}{\sum_{k=1}^{N} e^{V_k/\kappa}}$. The share of the national population in region j is then $\lambda_i = \Sigma_{i=1}^{N} \lambda_i^0 m_{ij} = \frac{e^{V_j/\kappa}}{\sum_{k=1}^{N} e^{V_k/\kappa}}$, since none of the terms in the right hand side of m_{ij} depend on the source region. Combining these expressions gives $\lambda_i = \frac{e^{V_j/\kappa}}{e^{W/\kappa}}$.

Table 4: Calibrated Model Parameters

Parameter	Value	Target / Description
β	0.3	Labour's share of gross output
$1-\beta-\eta$	0.6	Intermediate's share of output
$1-\alpha$	0.13	Housing's share of expenditure
θ	4	Elasticity of Trade
λ_n	*Region Specific*	Employment share
$\bar{L}_i$	*Region Specific*	National employment
Y_n	*Region Specific*	Initial nominal GDP
π_{ni}	*Pair Specific*	Bilateral trade shares

Notes: Displays model parameters, their targets, and a description. China's employment by province is from the national statistical yearbook. Employment for the world (region N) is from the Penn World Table. Bilateral trade shares between all pairs of China's provinces, and between each province and the rest of the world, is from China's extended Input-Output Tables for 2002. See text for more details.

3.6 Calibrating the Model

The model's equilibrium system, defined in equations 7 through 11, solves for changes in prices ($\hat{P}_n$), wages ($\hat{w}_n$), regional employment ($\hat{L}_n$) and trade flows ($\hat{\pi}_{ni}$) as a function of changes in trade costs $\hat{d}_{ni}$ and migration costs $\hat{C}_{ni}$. The exogenously specified parameters include the preference weight on goods consumption (α), labour's share of output (β), land's share of output (η), and a parameter governing the variance of the productivity distribution (θ). The remaining parameters include a region's initial nominal GDP $Y_i = w_i L_i$, trade shares π_{ni}, and labour allocations L_n. We describe the calibration in detail below and provide a brief summary in Table 4.

The household utility and production function parameters (α, β, η) are set such that labour's share of gross output is 20% and intermediate inputs' share is 60%. Land and structure's share follows from our constant returns to scale assumption, and thus $\eta = 0.2$. The 2002 extended input-output tables of China list total labour compensation, total intermediate input use, and gross output. The ratio of intermediate input use to gross output is 0.6112; we round to 0.6. We assume labour's share is larger than the ratio of labour compensation to gross output (approximately 0.2 in the input-output data) to reflect machinery and human capital used by workers, and set $\beta = 0.3$, which implies $\eta = 0.1$. Finally, to calibrate α, we use consumer expenditure data from China's most recent National Statistical Yearbook. The fraction of urban household spending on housing is 11.30% and for rural households is 15.47%. As a compromise between these values, we set $\alpha = 0.87$, implying the housing share of expenditures is 13%.[5]

The productivity dispersion parameter θ has received a great deal of attention in the literature. This parameter governs productivity dispersion across firms and, consequently, determines the sensitivity of trade flows to trade costs (higher θ implies *lower* elasticity). Anderson and van Wincoop (2004) review the literature and argue a value for θ between 5 and 10 is reasonable. For example, Alvarez and Lucas (2007) set $\theta = 6.67$, Eaton and Kortum (2002) set $\theta = 8.3$, Waugh (2010) finds $\theta = 7.9$ for OECD countries. Recently, however, Simonovska and Waugh (2011) find $\theta = 4.1$ when the bias inherent in Eaton and Kortum (2002)'s procedure, also used in Waugh (2010), is corrected. In what follows, we adopt this value ($\theta = 4$) but ensure our results are robust to alternative values.

Regional employment shares, for each of China's provinces and the rest of the world, are straightforward. China's statistical yearbook reports employment by province, and we adopt those numbers. The employment share in each province is reported in Table 6. Total national employment for China is then 636.508 million. Total employment in the rest of the world of 2,103 million is inferred from the Penn World Table as the total non-China employment in 2002.

Finally, to solve equation 7, we require a value for region i's initial total expenditure, Y_i. Given regional data on trade and employment, we find the value of Y_i that solve the initial trade balance condition. That is, given data for L_i and π_{ni}, find w_i that solves

$$w_i L_i = \sum_{n=1}^{N+1} \pi_{ni} w_n L_n.$$

Let w_i^* be the solution to this system, we define Y_i as $w_i^* L_i$. To do this, we use province level data on trade π_{ni} from China's extended 2002 input-output tables. We do not report the entire matrix here, but one can get a sense for the value of π_{ni} for each province by reviewing the regional trade patterns from Section 2.2.

[5]This number is not selected at random between 0.113 and 0.1547. It is also the weight given to housing in the spatial consumer price level data that we will employ later in the paper.

Initial real income differences across provinces V_i are set to match data on real GDP per capita. We have consumer price level (spatial) differences between 1985 and 2002 that can deflate nominal GDP per worker data by province. This price data includes housing, with a weight of 13%, which is consistent (by our construction) of the calibrated value for housing's weight in household preferences. Thus, the price index data corresponds to $P_n^{\alpha} r_n^{1-\alpha}$ in the model. We extrapolate spatial prices until 2007 using data on province-specific changes in GDP deflators from official sources. Given data on nominal GDP, employment, and price by province, we calculate real income as $\left(Y_n^{nominal}/L_n\right)/P_n$ and report the value (relative to the mean) in the third column of Table 6. Expressed relative to the mean, define

$$V_n = \frac{\left(Y_n^{nominal}/L_n\right)/P_n}{\frac{1}{N}\sum_{i=1}^{N}\left(Y_i^{nominal}/L_i\right)/P_i}.$$

What remains is to calibrate the variance of tastes parameter κ and the bilateral migration costs C_{ij}. Given a measure for κ, we can back out an estimate of migration costs using a procedure similar to the technique of Head and Ries (2001) and Novy (2013) for trade costs. Combine the expression for normalized migration flows from i to j $\left(\frac{m_{ij}}{m_{ii}} = e^{\left(V_j - V_i - C_{ij}\right)/\kappa}\right)$ with the normalized flows from j to i to yields

$$ln\left(\frac{m_{ij}m_{ji}}{m_{ii}m_{jj}}\right) = -\frac{1}{\kappa}\left(C_{ij} + C_{ji}\right).$$

Defining $\bar{C}_{ij} = \frac{c_{ij}+c_{ji}}{2}$, as the simple average migration cost between region i and j, we have

$$\bar{C}_{ij} = -\frac{\kappa}{2} ln\left(\frac{m_{ij}m_{ji}}{m_{ii}m_{jj}}\right).$$

To estimate the key migration parameter κ we must impose further structure on bilateral migration costs. If migration costs depend on symmetric bilateral factors, such as distance, as well as on origin- and destination-specific costs, then we can estimate

$$ln\left(\frac{m_{ijy}}{m_{iiy}}\right) = \frac{1}{\kappa} e^{-\delta(d_{ij}-1)} + \rho_{jy} + \rho_{iy} + \nu_{ijy},$$

where d_{ij} is the distance between source province i and destination province j, expressed relative to the average distance, δ is the distance-elasticity of migration costs, and the ρ's are origin- and destination-specific controls. The fixed effects here will capture any region-specific migration cost in addition to the region's real income level V. We estimate this with non-linear least squares and find that $\hat{\kappa} = 0.176$, with a 95% confidence interval of $[0.09, 0.26]$. The estimated distance-elasticity of migration costs is $\hat{\delta} = 0.397$, with an interval of $[0.21, 0.59]$. This is comparable to the estimate of the freight-rate-elasticity of trade costs (see, e.g., Hummels, 2001). Given this value for $\kappa = 0.17$, we back out migration costs $\bar{C}_{ij}$.

Before proceeding to the counterfactual simulations, we must address one complication from zeros in the migration matrix $\mathbf{m}$. Given our census data is a 0.2% sample, zeros are more likely small migration flows rather than true zeros. We infer the value of these zeros using fitted values from the above regression. All non-zero elements of $\mathbf{m}$ are unchanged. We take provincial employment in 2000 from aggregate data and infer the distribution of *Hukou* affiliations as $\mathbf{L^0} = \mathbf{L^1}'\mathbf{m}^{-1}$. Counterfactual employment in inferred from $\mathbf{L^0}$ and a simulated migration matrix. We may now proceed to our quantitative exercises.

4 Counterfactual Experiments and Discussion

This section outlines the main counterfactual experiments to quantify the relationship between trade liberalization and regional migration in China. We earlier presented evidence for large reductions in trade costs that varied across China's regions. We begin by examining the effect of these reductions. Following this, we present evidence for changes in migration costs. We simulate the effect of lower migration costs and also lowering migration and trade costs together.

4.1 Lower Trade Costs

With the full migration matrix now in place, we can proceed to simulate the model's response to various counterfactuals. Consider first the aggregate (national) consequences of lower trade and migration costs. Table 5 displays the change in international trade flows, aggregate welfare, and overall inter-provincial migration flows for each of our counterfactuals. Lower internal trade costs, not surprisingly, lower

Table 5: Counterfactual Aggregate Outcomes

Measured Cost	Change in Trade to GDP Ratio (p.p.)		Migrants	Income	Avg Real	Real	Aggregate
Reduction of	Internal	External	(millions)	Differences	Income	GDP	Welfare
Internal Trade	51.6	-3.3	3.1	-6.90%	10.1%	9.9%	9.8%
External Trade	-4.4	24.9	2.5	2.53%	3.7%	4.4%	3.1%
All Trade	44.9	19.4	4.8	-5.01%	13.8%	14.3%	12.8%
Migration	-0.1	0.2	10.7	-5.24%	1.0%	1.5%	0.1%
Trade & Migration	44.9	19.5	18.0	-12.51%	15.2%	16.5%	12.9%

Notes: Displays aggregate response to various counterfactuals. Trade costs and migration costs are reduced by the amount we measure in the text. The change in trade's share of GDP is displayed in terms of percentage point changes. That is, the 24.9 value for the external trade cost reduction implies international trade relative to GDP increased from 31.6% to 56.5%. We report the change in the variance of log real incomes across provinces in the last column. The initial variance of log real income is 0.2598.

the amount of international trade as households and firms reorient their purchase decisions towards domestic suppliers. The magnitudes are substantial. Our estimates imply that the the improvements in inter-provincial trade between 2002 and 2007 subtracted nearly 12% from international trade flows and lowered the international trade to GDP ratio by over three percentage points. Also in response, aggregate welfare dramatically increased by 10%. The resulting flow of migrants was relatively small, at just over 3 million.

Turning to lower external trade costs, which we attributed to joining the WTO, reveals a different pattern. With improved international trade, the total volume of trade increased by nearly 25 percentage points of GDP. The total volume increased by nearly 80%. Despite these large flows, the welfare gains from external trade liberalization are only one-third of the welfare gains from internal trade cost reductions. The number of between province migrants is also lower, at only 2.5 million. Lowering both external and internal trade costs predictably results in slightly lower international trade flows, more migrants, and higher welfare gains than liberalizing either separately. To generate much larger migration flows, something more than trade cost changes are required.

4.2 Lower Migration Costs

Recall $\bar{C}_{ij} = -\frac{\kappa}{2} ln\left(\frac{m_{ij}m_{ji}}{m_{ii}m_{jj}}\right)$ is symmetric and can only be determined for province pairs that experience worker flows in both directions. Nevertheless, it reveals some interesting patterns. In 2000, the average across all pairs was nearly 1.5, with a standard deviation of 0.2. In 2005, there was a close to uniform reduction in migration costs – falling to just over 1.3.

We plot the migration costs measured in 2005 compared to 2000 in Figure 5. The change in migration costs are $\Delta\bar{C}_{ij} = -\frac{\kappa}{2}\left[ln\left(\frac{m_{ij}m_{ji}}{m_{ii}m_{jj}}\right)_{2005} - ln\left(\frac{m_{ij}m_{ji}}{m_{ii}m_{jj}}\right)_{2000}\right]$. The typical province pair had migration costs in 2005 that were between 75% and 95% of their 2000 level, with little relationship to the initial level of migration costs.

Simulating the model response to these lower migration costs suggests over 10.7 million migrants moved as a result. The welfare gains are modest but perhaps most surprising of all is that trade volumes (both internal and external) are almost completely unresponsive. Migration costs and large scale between province migration does not necessarily translate into increases in trade.

4.3 Lowering Trade and Migration Costs

Simulating both trade and migration cost reductions together reveals the two reinforce each other's effect on migration and welfare. With easier migration flows, lower trade costs have larger welfare gains and more worker flows between provinces. Together, we estimate 18 million migrants moved in response to lower migration costs and lower internal and external trade costs. Welfare gains are nearly 13%, which is more than the combined welfare gains from trade cost and migration cost reductions performed separately. Finally, the increase in international trade flows is very similar to the trade liberalization experiment alone, which is not surprising as migration leads to little international trade response.

We can decompose the contribution to migration flows overall of lower trade costs and lower migration costs. Combined, 18 million workers move across provincial boundaries. With lower migration costs alone, this number is 10.7. So, lower trade costs results in an incremental migration flow of 7.3 million. With lower trade costs alone, 4.8 million migrants cross provincial boundaries. So, lower trade costs accounts for between 27% and 41% of the migration (respectively, 4.8/18 and 7.3/18).

At the province level, we report the change in employment and trade flows over all counterfactual experiments in Figures 6 and 7. The destination for migrants are consistently the coastal provinces, such as Shanghai, Tianjin, Beijing, and Guangdong. The source regions are from the interior provinces, such as Anhui, Sichuan, Hunan, among others. Overall employment for destination provinces increases more for external liberalizations than internal. For Shanghai, the change due to external trade cost reductions is actually larger than for migration cost reductions. The last panel of Figure 6 also displays an extremely close correlation to the data. Our measured reduction of trade and migration costs not only capture most of the aggregate number of migrants but also the spatial distribution of source and destination provinces.

The province level trade flow response to the various experiments is in line with the aggregate results. Little change results anywhere in terms of international trade flows when migration costs decline. Internal trade cost reductions also generate less international trade, mainly due to trade declines in a few key provinces; namely, Guangdong, Shanghai, and Tianjin. External trade cost reductions, on the other hand, drive very large increases in trade flows, especially for coastal regions.

4.4 Spatial Distribution of Gains

We display the spatial distribution of real income changes that result from the various experiments with and without migration or migration cost reductions in Table 10. Without migration, international trade liberalization increases coastal incomes substantially – 14% in Shanghai and 12% in Tianjin, for example. Allowing migration will spread the gains from trade to interior regions and dampen the gains in coastal areas. Lowering migration costs will further equalize gains. Shanghai, for example, experiences an income gain of only 2% as workers move in. Interior regions such as Sichuan and Anhui, which gained only 2% and 3%, respectively, without migration, see gains increase to 4% and 8% as workers move out. The income gains of lower internal and external trade costs, along with reduced migration frictions, lead to substantial gains in each province, most experience double-digit gains.

5 Conclusion

To be completed.

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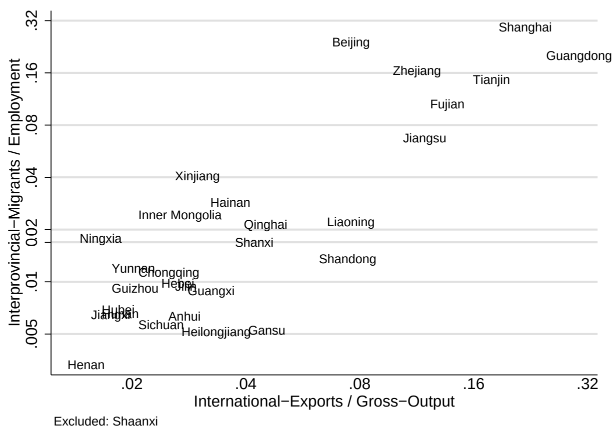
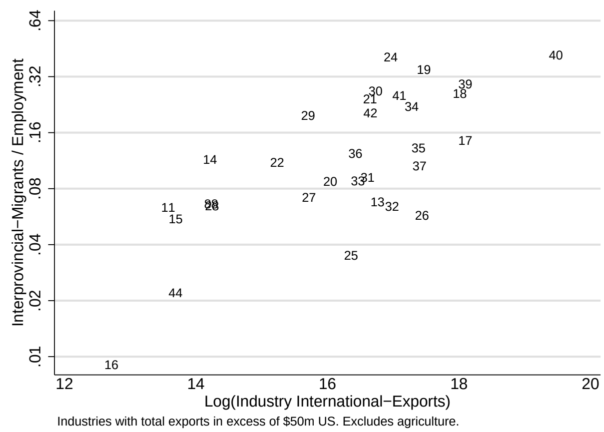
Figures and Tables

Figure 1: Migration and Employment Patterns in Census 2005

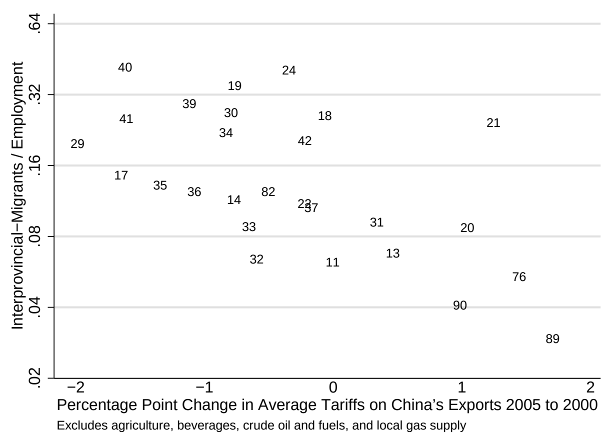
(a) Migrant Share of Employment and Provincial Exports



(b) Migrant Share of Employment and Industry Exports



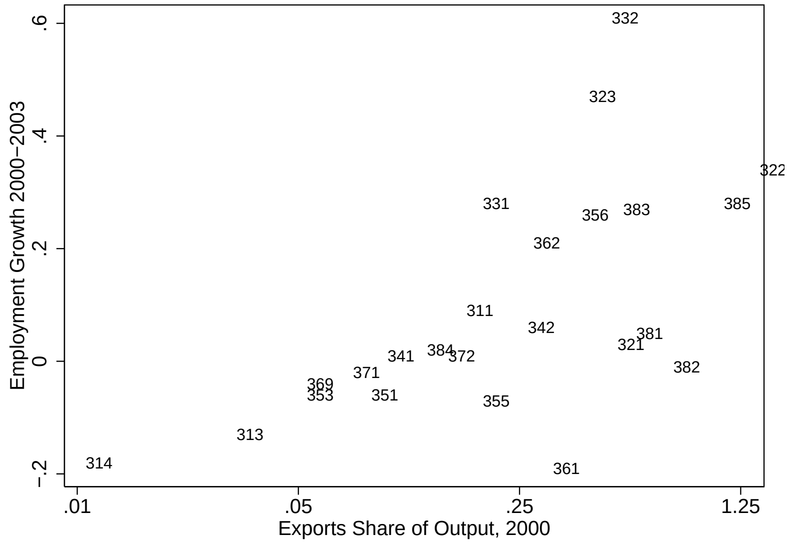
(c) Migrant Share of Employment and Tariffs Changes



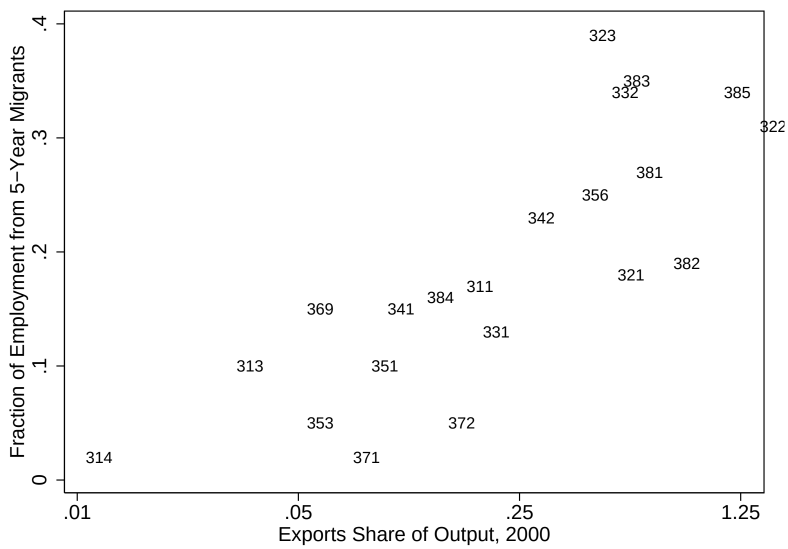
Note: Industries coded as two-digit GB2002 codes (China's industry classification system used in the 2005 Census). Exports by industry are from UN-COMTRADE, by ISIC Revision 3, manually linked to GB2002. Tariff data from the TRAINS database, simple average across product lines and import volume weighted across ISIC Rev. 3 to aggregate to GB2002. The capture percentage point changes in tariffs applied by the rest of the world on China's exports in 2005 minus those applied in 2000.

Figure 2: Migration and Employment, by Manufacturing Sector

(a) Employment Growth and Export Share



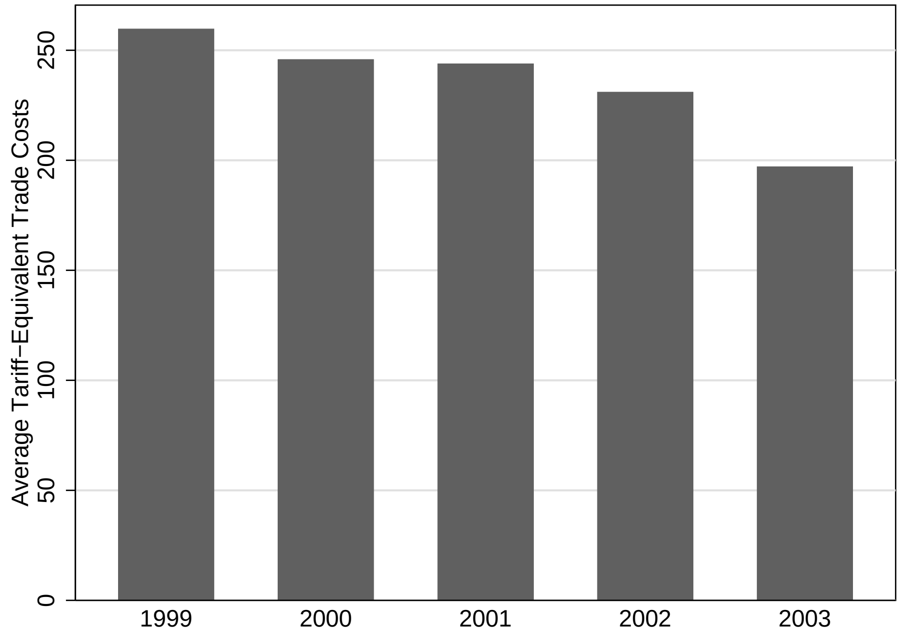
(b) Migrant Employment and Export Share



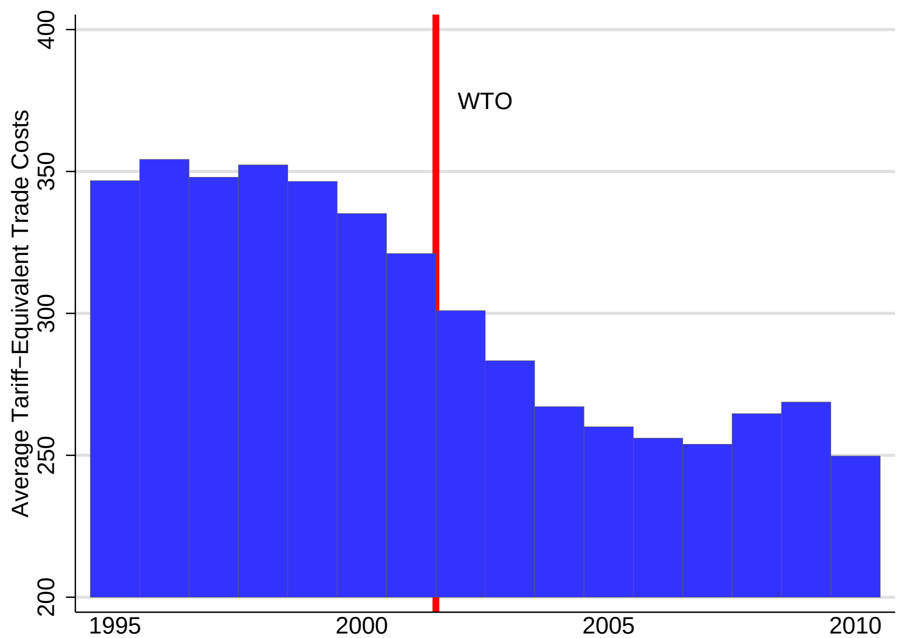
Note: Displays link between migrant employment and industry export orientation. Production, employment, and trade data from CEPII and migrant data inferred from Census 2005.

Figure 3: Trade Costs Between China and the World

(a) Our Trade Cost Estimates (Using CEPII Data)



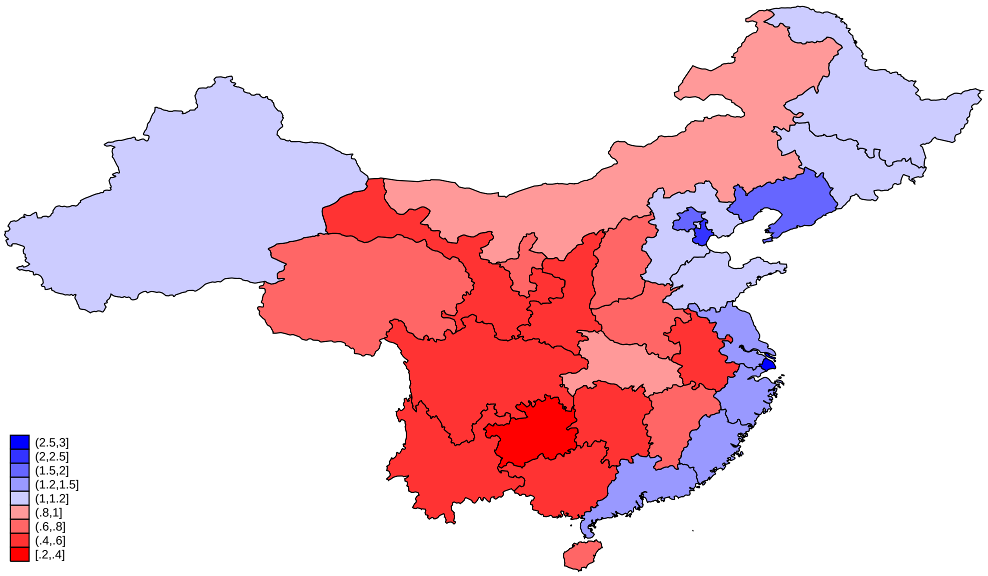
(b) World Bank UNESCAP Trade Cost Estimates



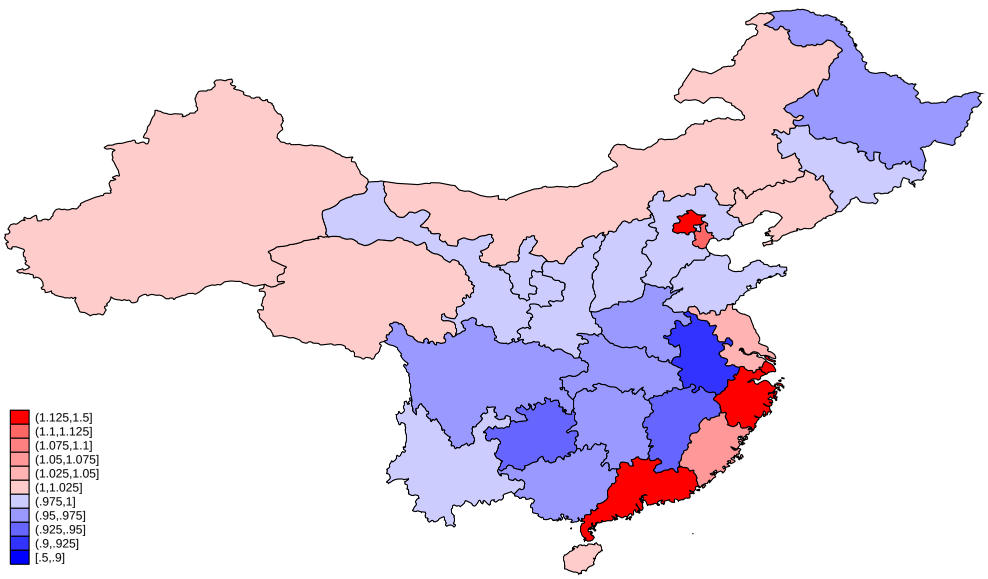
Note: Displays trade costs estimated through an expanded Head-Ries index as derived by Novy (2013). Panel a displays our estimates using the CEPII data on production and trade. Panel b displays the World Bank UNESCAP trade cost estimates, rescale such that $\theta = 4$ for comparability. See text for details.

Figure 4: Spatial Distribution of Real Incomes and Migration Flows

(a) Relative Real Income, μ_n

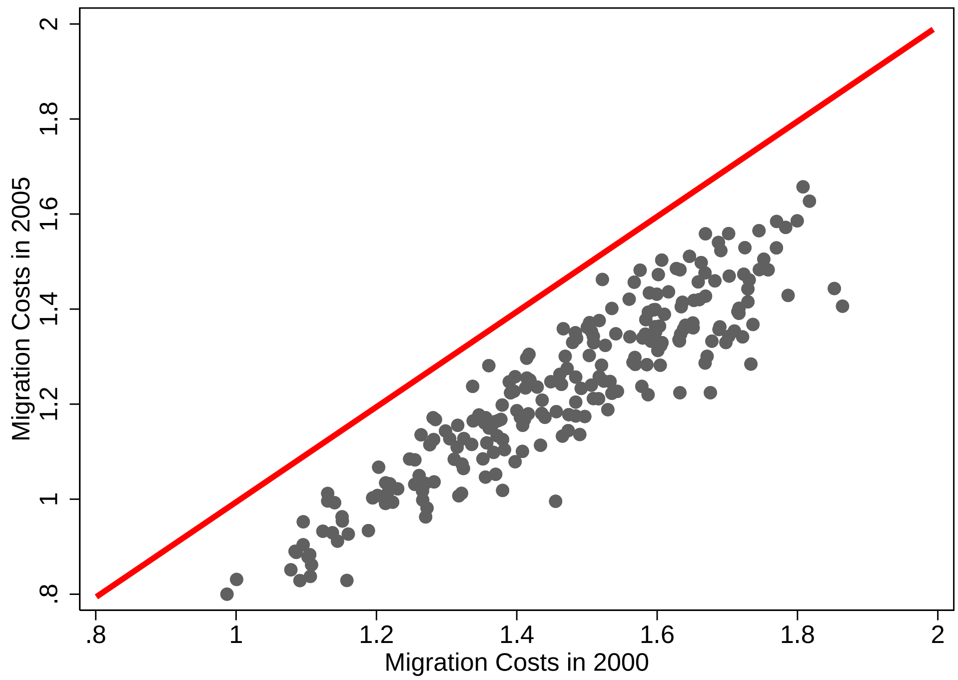


(b) Data: Migration for Work, 2002-2005



Note: Displays relative real income levels for each of China's provinces and the change in employment between 2002 and 2005 implied by migration for work purposes (frmo Census 2005).

Figure 5: Change in Measured Migration Costs



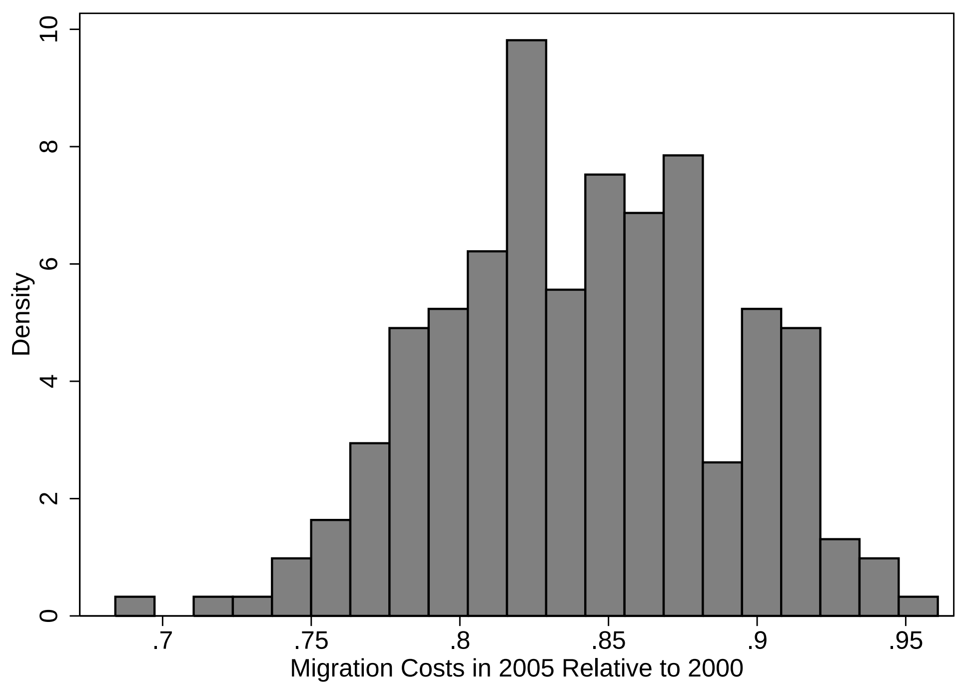
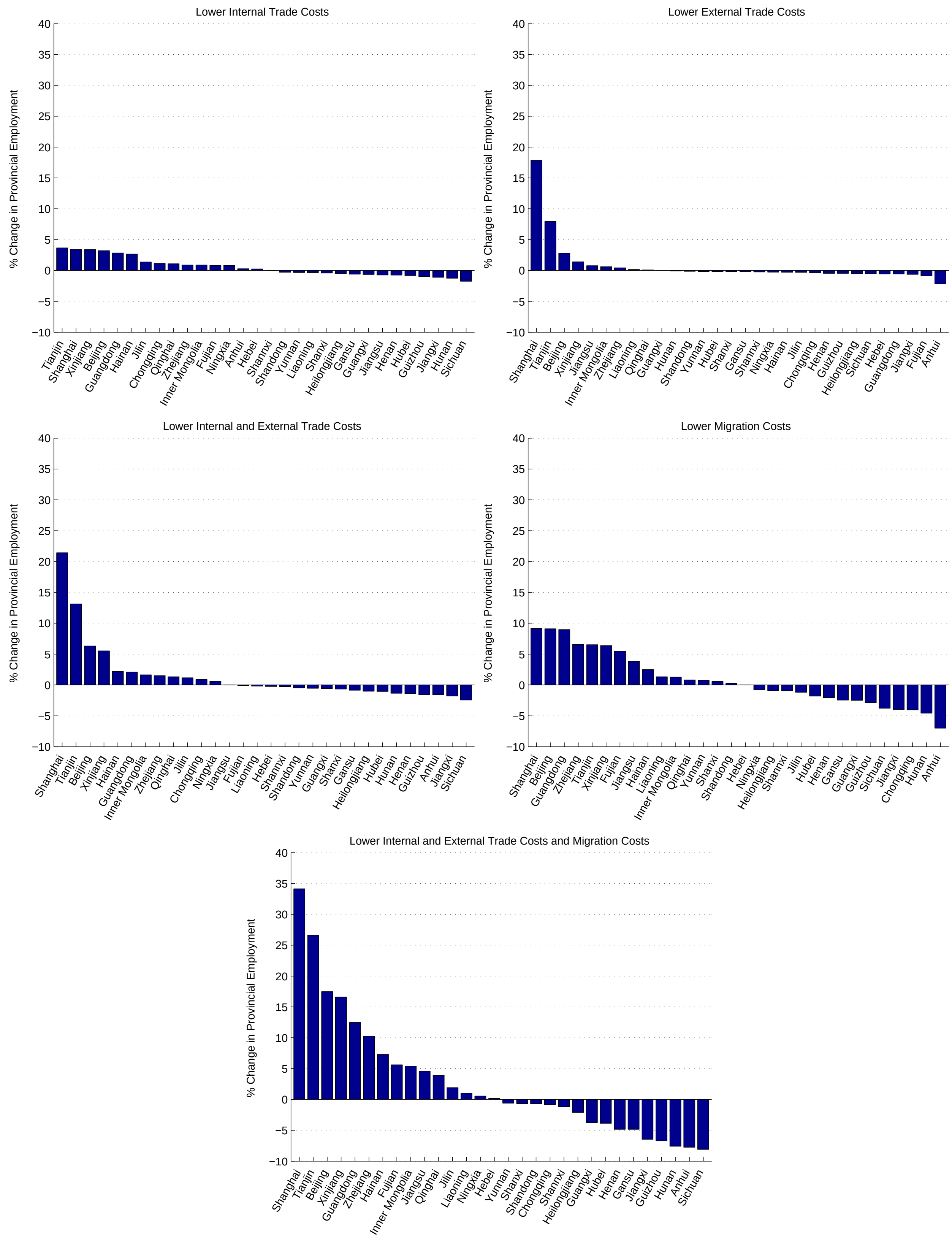
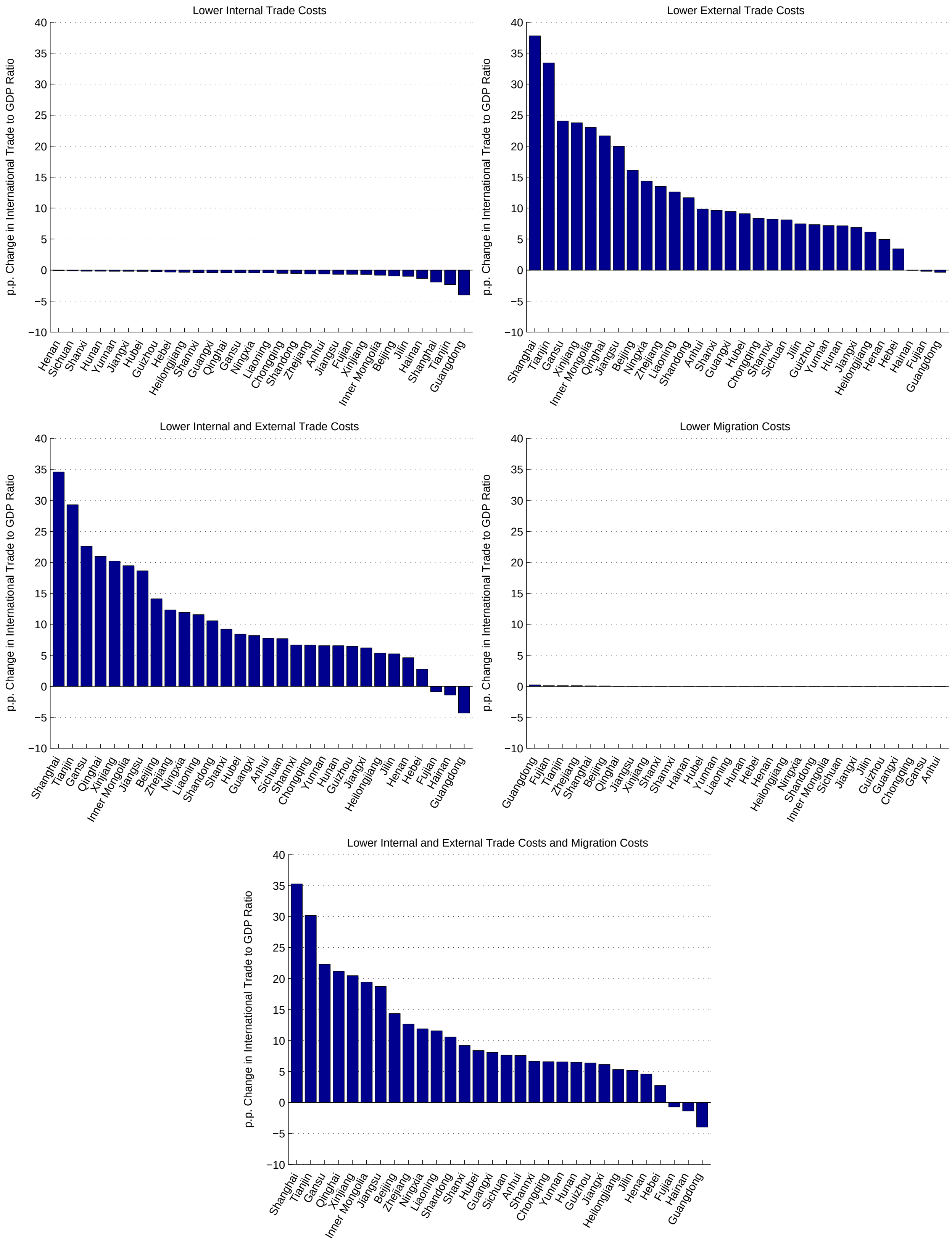


Figure 6: Change in Provincial Employment



Note: Displays the percentage change in total employment across provinces for various counterfactual experiments.

Figure 7: Change in International Trade/GDP



Note: Displays the percentage point change in the ratio of international trade flows (imports plus exports) to GDP across provinces for various counterfactual experiments.

Table 6: Summary Data for China's Provinces, 2002

Province	Employment Share	Home Bias	International Export Share of Total Production	Relative Real Income	Ratio of Net Three Year Migration to 2005 Employment
Anhui	0.053	0.619	0.024	0.56	-8.32%
Beijing	0.013	0.661	0.065	1.82	17.55%
Chongqing	0.026	0.545	0.020	0.72	-5.31%
Fujian	0.027	0.807	0.118	1.28	5.62%
Gansu	0.020	0.776	0.039	0.48	-1.56%
Guangdong	0.062	0.647	0.239	1.35	14.14%
Guangxi	0.040	0.694	0.027	0.50	-4.04%
Guizhou	0.033	0.718	0.017	0.29	-5.48%
Hainan	0.005	0.624	0.031	0.74	0.07%
Hebei	0.053	0.718	0.023	1.01	-1.10%
Heilongjiang	0.026	0.797	0.026	1.15	-2.58%
Henan	0.087	0.875	0.013	0.63	-4.33%
Hubei	0.039	0.857	0.016	0.88	-5.15%
Hunan	0.054	0.849	0.016	0.57	-5.25%
Inner Mongolia	0.016	0.775	0.020	1.00	3.56%
Jiangsu	0.055	0.802	0.100	1.45	-6.61%
Jiangxi	0.031	0.790	0.015	0.65	-1.21%
Jilin	0.017	0.554	0.025	1.13	0.73%
Liaoning	0.029	0.827	0.063	1.51	0.03%
Ningxia	0.004	0.633	0.014	0.68	-0.12%
Qinghai	0.004	0.640	0.038	0.66	0.71%
Shandong	0.075	0.830	0.060	1.11	-0.35%
Shanghai	0.012	0.645	0.179	2.67	23.06%
Shaanxi	0.029	0.758	0.001	0.57	-1.69%
Shanxi	0.022	0.858	0.036	0.80	-0.34%
Sichuan	0.069	0.881	0.020	0.58	-5.22%
Tianjin	0.006	0.552	0.153	2.28	10.51%
Xinjiang	0.011	0.757	0.025	1.11	2.09%
Yunnan	0.037	0.807	0.017	0.46	-0.34%
Zhejiang	0.045	0.743	0.094	1.37	11.89%

Notes: Home-bias reports total production for domestic use as a share of total absorption (calculated as 1/(1+I/D), where I is total imports and D is gross output less total exports). Net migration as a fraction of 2005 employment is measured as the difference between inflows and outflows of migrants between 2002 and 2005, as captured in the 2005 census.

Table 7: Employment by Industry, 2000 and 2005

Industry	Total Employment Levels 2000	2005	% Change
Agriculture	430,456,800	411,558,525	-4.39%
Mining and Quarrying	6,982,100	10,558,129	51.22%
Manufacturing	80,021,800	89,041,261	11.27%
Utilities	6,799,600	5,073,626	-25.38%
Construction	15,984,100	23,608,993	47.70%
Geological Prospecting and Water Management	2,962,100	795,769	-73.13%
Transport, Storage, Post, and Telecom Services	15,934,500	21,163,253	32.81%
Wholesale and Retail Trade, and Catering	37,912,900	59,374,065	56.61%
Finance and Insurance	8,578,200	3,772,039	-56.03%
Real Estate	3,928,300	2,352,179	-40.12%
Social Services	13,374,900	18,522,857	38.49%
Healthcare, Sports, and Social Welfare	1,461,800	7,980,420	445.93%
Education, Culture and Arts, Radio, Film, and TV	7,896,300	17,546,845	122.22%
Scientific Research and Polytechnic Services	333,700	1,443,059	332.44%
Government, Party, Etc...	17,059,500	17,211,324	0.89%
Other	18,829,900	9,775,045	-48.09%
Total	668,516,500	699,777,389	
From Holz (2006):	720,850,000	758,250,000	
Share the census captures:	92.7%	92.3%	

Table 8: Employment by Industry and Region, 2000 and 2005

	Employment in 2000				Employment in 2005			
	East	Middle	Northeast	West	East	Middle	Northeast	West
Agriculture	144,003,200	140,142,100	29,185,800	117,125,700	130,204,739	133,589,796	30,133,229	117,630,761
Mining and Quarrying	2,083,300	2,431,800	1,129,000	1,338,000	3,085,432	3,742,953	1,480,847	2,248,897
Manufacturing	51,115,200	13,817,200	6,136,900	8,952,500	61,129,267	14,887,977	5,297,513	7,726,503
Utilities	3,893,400	1,485,700	557,200	863,300	2,146,520	1,464,309	602,199	860,599
Construction	8,467,300	3,595,200	1,257,200	2,664,400	12,946,664	5,796,478	1,396,542	3,469,309
Geological Prospecting and Water Management	1,771,100	573,400	215,700	401,900	271,357	263,988	81,741	178,683
Transport, Storage, Post, and Telecom Services	6,827,800	4,218,500	2,036,900	2,851,300	9,422,982	6,110,891	2,297,478	3,331,903
Wholesale and Retail Trade, and Catering	18,647,600	9,016,500	3,800,200	6,448,600	29,733,735	14,747,624	5,329,514	9,563,192
Finance and Insurance	4,132,400	1,988,900	750,100	1,706,800	1,765,619	937,813	457,570	611,037
Real Estate	1,720,400	1,037,500	484,200	686,200	1,505,858	342,388	198,563	305,369
Social Services	6,794,800	2,881,000	1,535,800	2,163,300	9,197,180	4,424,297	1,954,916	2,946,464
Healthcare, Sports, and Social Welfare	807,200	252,600	104,500	297,500	3,364,870	2,274,286	816,584	1,524,680
Education, Culture and Arts, Radio, Film, and TV	3,357,000	2,147,300	899,500	1,492,500	7,189,365	5,054,902	1,700,249	3,602,329
Scientific Research and Polytechnic Services	160,900	76,000	39,500	57,300	836,281	238,903	142,294	225,580
Government, Party, Etc...	6,908,800	4,847,600	1,726,300	3,576,800	7,078,403	5,054,844	1,731,502	3,346,576
Other	8,009,300	5,237,500	1,974,000	3,609,100	5,292,035	1,991,362	1,239,084	1,252,564

Table 9: Inter-Provincial Migrants by Industry and Region, 2000 and 2005

	Migrants in 2005 by Industry of Employment				Migrants as Fraction of Employment Growth			
	East	Middle	Northeast	West	East	Middle	Northeast	West
Agriculture	818,426	144,271	89,291	306,833	-5.93%	-2.20%	9.42%	**60.75%**
Mining and Quarrying	138,285	158,778	24,590	85,093	13.80%	12.11%	6.99%	9.34%
Manufacturing	15,345,897	309,910	175,601	253,768	**153.24%**	28.94%	-20.92%	-20.70%
Utilities	74,398	11,134	1,891	18,452	-4.26%	-52.05%	4.20%	-683.16%
Construction	2,475,960	236,613	74,876	261,446	**55.27%**	10.75%	53.74%	32.48%
Geological Prospecting and Water Management	13,148	1,340	645	609	-0.88%	-0.43%	-0.48%	-0.27%
Transport, Storage, Post, and Telecom Services	697,468	54,739	19,799	63,147	**26.88%**	2.89%	7.60%	13.14%
Wholesale and Retail Trade, and Catering	4,017,347	417,291	225,842	537,288	**36.24%**	7.28%	14.77%	17.25%
Finance and Insurance	32,864	2,672	994	3,525	-1.39%	-0.25%	-0.34%	-0.32%
Real Estate	220,790	14,524	6,199	9,151	-102.91%	-2.09%	-2.17%	-2.40%
Social Services	1,651,331	107,123	63,756	141,817	**68.74%**	6.94%	15.21%	18.11%
Healthcare, Sports, and Social Welfare	105,207	10,460	3,326	6,161	4.11%	0.52%	0.47%	0.50%
Education, Culture and Arts, Radio, Film, and TV	181,173	19,280	9,769	16,687	4.73%	0.66%	1.22%	0.79%
Scientific Research and Polytechnic Services	58,182	3,929	393	2,651	8.61%	2.41%	0.38%	1.58%
Government, Party, Etc...	84,099	4,609	2,076	8,108	**49.59%**	2.22%	39.91%	-3.52%
Other	695,408	32,332	22,596	33,790	-25.59%	-1.00%	-3.07%	-1.43%

Table 10: Simulated Real Income Change from Lower Trade Costs, $\hat{V}_n$

	Lower External Costs			Lower Internal Costs			Lower External and Internal Costs		
		Migration Cost			Migration Cost			Migration Cost	
Province	Immobile Labour	No Change	Measured Change	Immobile Labour	No Change	Measured Change	Immobile Labour	No Change	Measured Change
Anhui	1.03	1.04	1.08	1.21	1.21	1.25	1.24	1.25	1.30
Beijing	1.05	1.04	1.00	1.09	1.08	1.04	1.14	1.11	1.07
Chongqing	1.02	1.03	1.05	1.21	1.20	1.22	1.23	1.23	1.24
Fujian	1.00	1.00	0.98	1.09	1.08	1.06	1.08	1.09	1.06
Gansu	1.07	1.07	1.09	1.15	1.15	1.18	1.22	1.23	1.26
Guangdong	1.00	1.00	0.97	1.11	1.10	1.05	1.11	1.10	1.06
Guangxi	1.03	1.03	1.04	1.13	1.14	1.16	1.16	1.16	1.18
Guizhou	1.02	1.02	1.04	1.12	1.13	1.15	1.14	1.15	1.18
Hainan	1.00	1.00	0.99	1.29	1.27	1.24	1.28	1.27	1.24
Hebei	1.01	1.01	1.01	1.16	1.16	1.16	1.16	1.17	1.17
Heilongjiang	1.02	1.02	1.02	1.08	1.08	1.09	1.09	1.10	1.11
Henan	1.01	1.02	1.03	1.06	1.07	1.08	1.08	1.08	1.10
Hubei	1.03	1.03	1.04	1.06	1.06	1.08	1.09	1.09	1.11
Hunan	1.02	1.02	1.04	1.07	1.08	1.11	1.09	1.10	1.13
Inner Mongolia	1.08	1.07	1.06	1.17	1.16	1.15	1.24	1.24	1.22
Jiangsu	1.06	1.06	1.04	1.04	1.05	1.03	1.11	1.11	1.09
Jiangxi	1.02	1.02	1.04	1.10	1.10	1.13	1.11	1.12	1.15
Jilin	1.02	1.02	1.03	1.22	1.22	1.22	1.24	1.24	1.24
Liaoning	1.04	1.04	1.03	1.05	1.06	1.05	1.09	1.09	1.09
Ningxia	1.04	1.04	1.05	1.26	1.26	1.26	1.30	1.30	1.30
Qinghai	1.06	1.07	1.06	1.26	1.25	1.24	1.32	1.32	1.31
Shandong	1.03	1.04	1.04	1.06	1.06	1.06	1.09	1.10	1.10
Shanghai	1.14	1.06	1.02	1.06	1.05	1.01	1.21	1.10	1.05
Shannxi	1.03	1.03	1.04	1.20	1.20	1.20	1.22	1.23	1.23
Shanxi	1.03	1.03	1.03	1.07	1.07	1.07	1.10	1.10	1.10
Sichuan	1.02	1.02	1.04	1.05	1.05	1.08	1.07	1.08	1.11
Tianjin	1.12	1.08	1.03	1.10	1.09	1.04	1.22	1.15	1.09
Xinjiang	1.07	1.07	1.04	1.18	1.16	1.12	1.25	1.22	1.17
Yunnan	1.02	1.02	1.02	1.08	1.08	1.08	1.10	1.10	1.11
Zhejiang	1.04	1.04	1.01	1.08	1.08	1.05	1.12	1.12	1.08

Notes: Shows changes in provincial real incomes from various counterfactual experiments.