Internal Geography, Labor Mobility, and the Distributional Impacts of Trade*

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Abstract

This paper develops a spatial equilibrium model to quantify the aggregate and distributional impacts of *international* trade in an economy with *intra-national* trade and migration costs. I apply the framework to China and conduct counterfactual experiments. I find that international trade increases the skill premium within a region, as well as the between-region inequality for workers with similar skills. Both components are quantitatively important for the increase in aggregate inequality after trade liberalization. Reforms in domestic labor/goods markets can alleviate the effects of trade on inequality, but do so at the expense of smaller aggregate gains from trade.

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Keywords: Gains from trade, distributional effects of trade policy, migration, spatial inequality, skill premium, China

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1 Introduction

In recent decades we have witnessed increasing integration of large developing countries, such as Brazil, China, India, and Mexico, into the global economy. This trend has renewed the interest of policymakers and academics in understanding the impacts of globalization on income and inequality.

Existing research on this topic focuses on the impacts of international trade on workers in different industries, or with different skills, but abstracts from the geographic dimension of the distributional impacts.[1] Consider workers living far away from a nation's ports. Because of the high *intra-national* trade costs, they might not benefit much from cheaper imported products, and international trade can exacerbate the intra-national inequality in living standards. Moreover, in a world with both skilled and unskilled workers, if one type of workers is more mobile than the other, and responds to trade liberalization by migrating to the coast, then the workers left behind might even lose from trade. These losses can be independent of regional sectoral specializations. This geographic margin in the distributional impacts of trade is not only plausible, but also empirically relevant.[2]

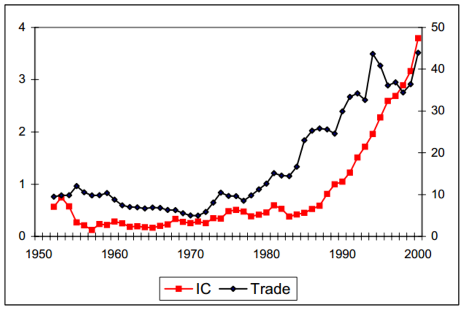
The scenario discussed above gives rise to two related questions: what are a country's welfare gains from *international* trade, in the presence of *intra-national* trade and migration costs? How does international trade liberalization affect the between-region inequality—among workers with similar level of skills, and the within-region inequality—between different types of workers?

To answer these two questions, this paper develops a tractable spatial equilibrium model with multiple regions connected to each other through costly trade and migration. These regions, except for the last one, reserved for the rest of the world, represent regions within a country. On the production side, regions have different levels of productivity, and trade with each other. To capture an important mechanism through which trade affects wage inequality, I incorporate trade in capital goods and capital-skill complementarity in production. Production and trade determine the demand for labor, and the supply of goods, in all regions. On the worker side, workers decide where to work, based on the utility they would obtain from all potential destinations, which in turn depend on region-specific amenities, prices, and wages, as well as worker-specific labor productivity draws. The model further allows migrants to send remittances to their hometowns, an important channel

[1] More discussion on existing literature may be found in the next section.

[2] Limao and Venables (2001) documents that poor infrastructures dampen a country's participation in international trade; Atkin and Donaldson (2012) estimates the intra-national trade costs to be 4-6 times larger in their sample of African countries than in the United States. Topalova (2010) shows that in India, trade liberalization hurt the poorest workers because of their limited inter-regional and inter-sectoral mobility. See also Kanbur and Venables (2005) for an excellent overview of the UNU-Wider project on "Spatial disparities in development," which analyzes evidence in over 50 developing countries, and concludes that international trade and the lack of infrastructure are two important factors in the increasing spatial disparities in many of these countries.

Figure 1: Trade and Growth Inequality in China



Source: Figure 5 in Kanbur and Zhang (2005). IC (left axis) is the measure of inland-coast inequality in China, Trade (right axis) is defined as (import+export)/GDP

through which migration may affect welfare.[3] Workers' migration and consumption decisions determine the supply of labor, and the demand for goods, in all regions. In equilibrium, prices and the distribution of workers are determined simultaneously, so that all labor and goods markets clear.

I calibrate the model to the 2005 Chinese economy. In my calibration, a region in the model corresponds to a prefecture city in China. The key parameters of the model are migration costs and trade costs, which I estimate using information on migration flows, constructed from individual-level data, and information on inter-provincial trade flows. I calibrate the remaining parameters, governing worker preference, production technologies, and region-specific productivity and amenities, using various micro and macro data sources.

The coexistence of rapid trade growth, large spatial inequality, and significant frictions associated with domestic markets for factors and goods, makes China a useful setting for this study. As is well known, China has experienced rapid integration into world trade since its economic reform in 1978, and the process accelerated after China joined the WTO in 2001. At the same time, China has high intra-national trade costs, and important distortions in the labor markets. Perhaps partially due to these intra-national frictions, China's economic growth over the past decades has been uneven. Figure (1), taken from Kanbur and Zhang (2005), plots trade growth and the coast-inland inequality in per capita consumption. As the figure shows, the inter-regional inequality grew rapidly during the period of fast trade expansion.

I examine the distribution of the gains from international trade within China, by shutting down the trade between the model economy and the rest of the world. In line with results from papers without internal geography, the average (across regions and worker groups, weighted by population) gains from trade are around 7.5%. However, the welfare gains are distributed unevenly.

[3]For example, Yang (2008) finds remittances from immigrants have important implications for domestic human capital accumulation and entrepreneurship for household members who remain in the hometown.

Along the skill dimension, on average, skilled workers gain 11%, while unskilled workers gain only 5%, so the average skill premium increases by 6%. Among workers with similar skills, the impacts differ, too. For example, among urban unskilled workers, some gain as much as 20%, while others experience 2% welfare losses. The geographic location of a region is important: regions on the coast reap most of the welfare gains, and regions in the interior benefit little. The aggregate inequality, as measured by the Theil index, increases by 8% after the international trade liberalization in China. The geographic dimension—the increases in inequality between geographic regions—accounts for 64% of the increase, and the skill dimension—the increase in within-region inequality—accounts for the rest. Despite the rise in inequality, however, only the unskilled workers from a dozen of regions experience welfare losses. Therefore, there is enough scope for government redistribution to ensure that trade liberalization is a Pareto improvement for China.

Consistent with existing reduced-form evidence (Han et al., 2012), there is an active interaction between the geographic dimension and the skill dimension: the rises in regional skill premia are larger in coastal regions, that is, there is a negative gradient in changes in skill premia with respect to regions' distances to the coast. In addition to capital-skill complementarity, which intuitively increases skill premia by more, in regions that import more capital goods, I uncover two forces behind the change in the gradient of skill premia, both of which are inherently related to geography. First, because capital and manufacturing industries use intermediate varieties more intensively, they tend to locate in regions with better access to suppliers. After trade liberalization, the coastal regions experience larger increase in access to the foreign suppliers and therefore have stronger comparative advantages in these industries. As a result, coastal regions specialize in capital and manufacturing industries, which hire skilled workers more intensively, and interior regions specialize in the unskilled-intensive agricultural industry. This change in the *domestic* specialization pattern increases skill premia on the coast and decreases skill premia in the interior. Because this channel works through the factor content of intra-national trade, I call it "Domestic Stolper-Samuelson Effect."[4] To the best of my knowledge, this is a novel channel in the literature. An implication of this channel for empirical studies is that in measuring a region's exposure to international trade, it is important to take into account not only international trade but also the changes in domestic trade, as responses to the reductions in international trade barriers.

The second force is related to the differential mobility of skilled and unskilled workers. Because the estimated migration costs are lower for skilled workers, more skilled workers respond to trade liberalization by migrating out of their hometowns in the interior towards the coast, resulting in higher skill shares on the coast, and lower skill shares in the interior. This channel decreases

[4] The standard Stolper-Samuelson effect, which operates through international specialization, is less important here, as the trade between China and the ROW is largely within sector.

skill premia on the coast and increases skill premia in the interior, offsetting the "Domestic Stolper Samuelson Effect".

I show that both forces are quantitatively important for the changes in skill premia after trade. Incorporating the internal geography of a country is thus relevant for our understanding of the distributional impacts of trade, along both the geographic dimension and the skill dimension.

To shed light on how domestic frictions affect the welfare impacts of trade, I conduct four additional hypothetical international trade liberalization experiments. The only difference among these experiments is that the model "China" in these economies has either inter-provincial trade costs, or inter-provincial migration costs, or both, set at the U.S. level. These experiments find that reducing frictions in domestic markets for either goods or labor can alleviate the effects of international trade liberalization on spatial inequality, but the effects on the trade-induced increases in regional skill premia are limited. When internal frictions, in particular domestic trade costs, are smaller, the country participates less actively in, and therefore benefits less from, the international trade integration. Reforms within a country are thus substitutable to trade liberalization at the national border. In the experiment in which frictions in domestic markets for goods and labor are both reduced, the effect of trade on spatial inequality is further reduced. However, the welfare gains from trade also further decrease—different domestic reforms are complementary in alleviating the trade-induced inequality, but as the domestic markets become better integrated from within, the gains from trade are also smaller.

2 Related Literature

This paper contributes to the literature on the impacts of trade on inequality. Existing studies have focused on inequality along different dimensions: skilled versus unskilled workers, managers versus employees, employees in exporting firms versus in non-exporting firms, workers with experiences in different sectors, and workers in different local labor markets.[5] In contrast to the existing literature, this paper studies the geographic dimension and moreover, shows that modeling the geographic dimension is important, even when one's interest is in the skill dimension. The analysis in this paper takes a structural approach, so it is able to speak to both the aggregate and the distributional impacts in a unified framework. This is attractive because policy-making usually requires

[5] Goldberg and Pavcnik (2007) offers a review on the effects of globalization on various measures of inequality, including the skill premium; Ma (2013) and Tang (2014) study inequality between top income earners and the rest of the population; Helpman et al. (2012) studies trade and the exporter premium both theoretically and empirically; Dix-Carneiro (2014) and Cosar (2013) study the impacts of trade on workers with different sector-specific experience; Levchenko and Zhang (2013) uses a framework similar to this paper to assess the impacts of trade under different assumptions on the inter-sectoral mobility of labor and capital; Autor et al. (2013), Kovak (2013) and Dix-Carneiro and Kovak (2014) focus on the impacts of trade on different local labor markets, but in settings in which the differential impacts are only driven by sectoral specializations of regions, not geography.

weighing the welfare gains from trade against trade's effects on inequality, and the aggregate gains computed from a frictionless model are not directly comparable to the inequality impacts estimated from the real world data, in which internal frictions play an important role.

The model in the paper relates to the recent quantitative trade literature, pioneered by Eaton and Kortum (2002).[6] The production side of the economy builds on Caliendo and Parro (Forthcoming) in modelling input-output linkages, and on Parro (2013) and Burstein et al. (2013) in incorporating trade in capital goods and capital-skill complementarity. The focus of the present paper is similar to that of Redding (2012), which studies the gains from trade, taking into account the mobility of labor within a country. This paper extends Redding (2012)'s framework to incorporate multiple types of workers and estimate their differential mobility. This extension makes possible an analysis of the distributional impacts of trade along both skill and geographic dimensions, connecting this literature to a large literature on trade and the skill premium. The results also highlight that differential mobility plays a crucial role in determining the distributional effects of trade. Also closely related to this literature is an economic geography literature that examines the interaction between international trade and the distribution of economic activities within a country.[7] This strand of literature, however, typically treats workers as perfectly mobile, ruling out the analysis of the distributional impacts.

Two contemporaneous papers, Monte (2014) and Tombe and Zhu (2015), also extend Redding (2012) to examine issues related to trade and labor mobility frictions. Neither paper differentiates between skilled and unskilled workers; in contrast, the distributional impacts of trade on these two different groups of workers, and how these impacts interact with internal geography, are at the center of the present study. In addition, while Tombe and Zhu (2015) adopts a one-sector model, the sector specialization of regions plays an important role in the effects of trade on inequality in the present paper.[8]

Finally, this paper contributes to the research on trade (both internally and internationally), and internal migration in China. Existing studies have documented the differences in exposures to

[6] Recent contributions to this literature include Alvarez and Lucas (2007), Arkolakis et al. (2012), Caliendo and Parro (Forthcoming), di Giovanni et al. (2013), Hsieh and Ossa (2011), Ramondo et al. (2014), Edmond et al. (2012), and Caliendo et al. (2014), among others. See Costinot and Rodrłguez-Clare (2013) for a review of this literature.

[7] See for example, Krugman and Elizondo (1996), Venables and Limao (2002), and Hanson (2001, 2005) for earlier contributions. More recent studies, such as Allen and Arkolakis (2014) and Cosar and Fajgelbaum (Forthcoming), develop quantitative models to take to the data.

[8] In terms of focus, Monte (2014) studies how within-city commuting costs affect a city's response to international trade, abstracting from domestic trade costs and migration. Tombe and Zhu (2015) mainly analyzes among the measured domestic and international reforms, and the measured productivity improvements, which is important for the changes in welfare and income differences at the provincial level during 2000-2005 for China. The present paper instead focuses on the long-run impacts of international trade openness, dating back to 1978, and the interaction between trade liberalization and hypothetical domestic reforms using city-level data wherever possible. The time span of the analysis is consistent with how migration decisions are treated—migration is a once-for-life choice in the model and constructed based on birthplace in the data.

international trade, among Chinese regions (Wei and Wu, 2001; Kanbur and Zhang, 2005), the lack of integration between these regions, due to domestic trade costs and local protectionism (Young, 2000; Poncet, 2005; Tombe and Winter, 2014; and Bai et al., 2004), and the high rural-urban and inter-regional migration costs (Au and Henderson, 2006; Zhao, 1999). In the context of the existing literature, the contribution of this paper is to combine trade and migration in a tractable framework and examine the welfare implications of international trade liberalization.

3 Background and Descriptive Statistics

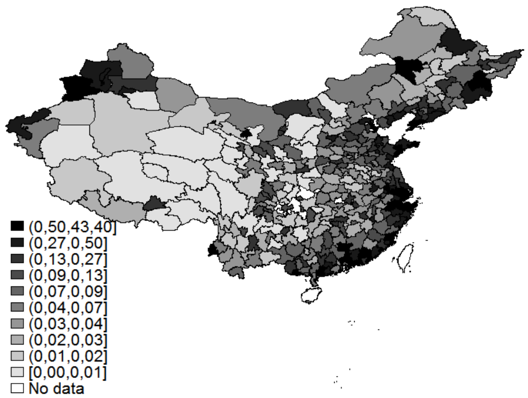
To motivate the key elements in the quantitative framework, in this section, I document some important features about the Chinese economy. The data used is discussed in Section 5.

To give an overview of the distribution of economic activities in China, Panels (a)-(d) in Figure (2) plots, by prefecture city, trade openness, urbanization rate, average wage for unskilled workers, and employment.[9] One general pattern emerging from these figures is that the eastern part of the country, the coastal areas in particular, tends to be more open and more urbanized, and tends to offer higher wages to unskilled workers. (The exceptions are a few cities in the northwest, with high urbanization rates and low population density: these are mostly oil-producing desert cities.) Most employment is concentrated in the eastern part of the country. However, it is the interior area of eastern China, rather than the coastal area with higher wages, that exhibits the highest employment density, suggesting there might be important barriers to migration. Panels (e) and (f) plot the distributions of skilled workers and the average urban skill premia. There, the patterns are less systematic, but there are still large regional disparities. In all figures, there is considerable heterogeneity, even among cities that are geographically close to each other; the substantial differences across regions also highlight the importance of internal trade and migration costs. To accommodate the large regional disparities, in the quantitative framework, I will focus on the city level and incorporate trade and migration costs between cities.

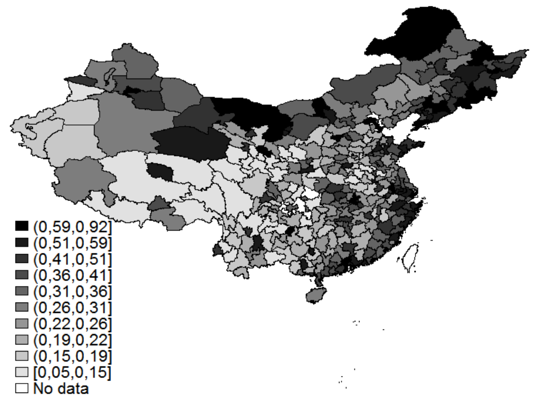
Despite the well-known restrictions on worker mobility in China, migration is an important phenomenon of the economy. Table (1) reports summary statistics on migration. In the urban labor force, on average, 11% of workers were born in other provinces, while 19% were born in other counties within the same province. Further, 94% of inter-provincial migrants and 57% of intra-provincial migrants are skilled; among local urban workers, only 48% are skilled. The difference in skill compositions reveals that skilled workers are more likely to migrate than unskilled workers, particularly for long-distance migration. The patterns are quite different in the rural sector: the shares of inter- and intra-provincial migrants are both 5%, much smaller than in the urban sector; the share of skilled workers is also smaller among migrants than among local workers. In

[9] There are, in total, 34 provinces and 340 prefecture-level jurisdictions in China.

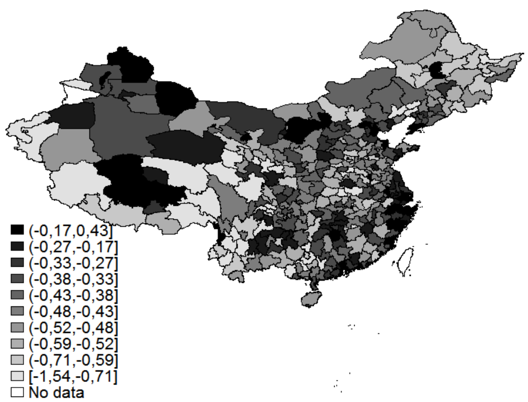
Figure 2: City-level Statistics



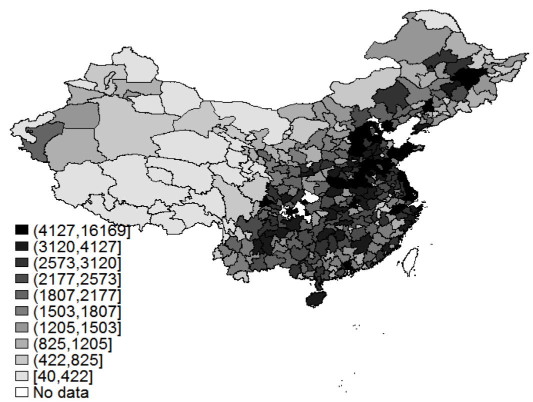
(a) Trade Openness



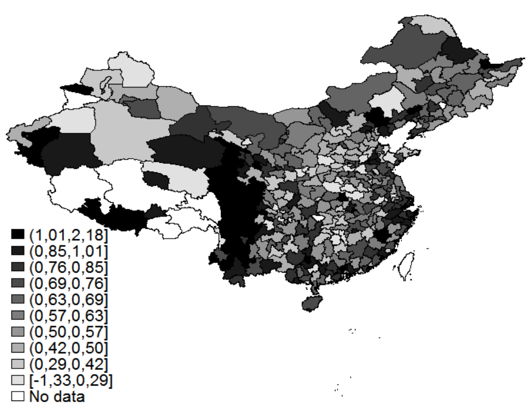
(b) Share of Urban Employment



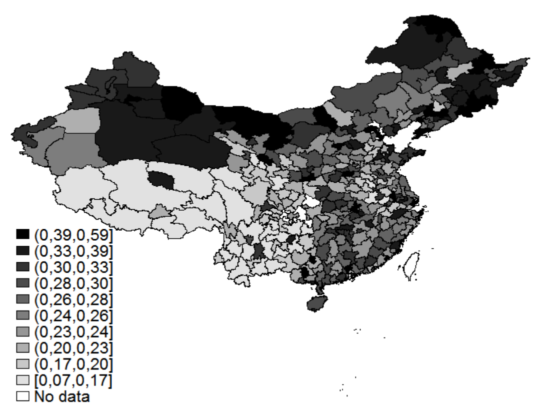
(c) Average Urban Unskilled Wage



(d) City-level Employment



(e) Average Urban Skill Premia



(f) Share of Skilled Workers

Source: Author's calculation based on 2005 statistics yearbook (Panel a), population census (Panels b through f)

Table 1: Summary Statistics for City-Level Variables

	Variable	Mean	Median	Std	N
Urban Sector	Share of inter-province migrants	0.11	0.07	0.11	340
	Share of intra-province migrants	0.19	0.17	0.10	340
	Skill share in inter-provincial migrants	0.94	0.92	0.39	340
	Skill share in intra-provincial migrants	0.57	0.58	0.15	340
	Skill share in employment	0.48	0.48	0.09	340
Rural Sector	Share of inter-province migrants	0.05	0.02	0.10	339
	Share of intra-province migrants	0.05	0.03	0.06	339
	Skill share in inter-provincial migrants	0.12	0.08	0.16	339
	Skill share in intra-provincial migrants	0.14	0.11	0.14	339
	Skill share in employment	0.16	0.16	0.05	339

Notes: Source: authors' calculation based on the 2000 census. Sample includes all prefecture-level jurisdictions, four of which are prefecture-level military base. Migration is defined based on the difference between the place of residence and the place of birth.

light of these differences in migration patterns between skilled and unskilled workers and between rural and urban destinations, in the quantitative framework I allow for differential mobility and incorporate the distinction between rural and urban sectors.

4 Theoretical Framework

4.1 The Environment

There are $2N + 1$ regions in the economy. These regions consist of rural and urban sectors of the N Chinese cities, in total $2N$ regions, and one last region that represents the rest of the world (ROW). Denote the set of regions **G**. I will use $o \in \mathbf{G}$ and $d \in \mathbf{G}$ to refer to the origin and destination of trade and migration flows. I also introduce **R** and **U** to denote the rural and urban subsets of **G**: $\mathbf{G} = \mathbf{R} \bigcup \mathbf{U}$. There are four production industries in the economy: agricultural (A), capital and equipment (K), other manufacturing (M), and service (S). Agricultural industry is located in rural regions, and the three other industries are located in urban regions. A, K, and M are tradable; S is non-tradable. In the following, I describe the decisions of workers and firms, and define the equilibrium of the economy.

4.2 Workers

There are two types of workers, with different levels of skill. I use e, $e \in \{h, l\}$ to denote the skill level of a worker, where h and l stand for high-skill and low-skill, respectively. A worker's sole source of income is his or her wage, which depends on the wage rate for each labor unit, and the number of labor units a worker possesses—or a worker's productivity—in the local labor market. I assume a worker's productivity in any region is a random draw from a given distribution, to be specified below. The random draw assumption captures in a reduced-form way the match quality between a worker and a region. Workers value both amenities and consumption goods. They choose where to live *within* the country based on regional outcomes—amenities, wages and prices—and individual-level outcomes—their productivity draws across regions.[10] The idiosyncracy of workers' productivity draws allows the model to generate bilateral migration flows, a prominent feature of data.

4.2.1 Preference

Based on a migrant survey, Akay et al. (2012) documents that migrants in China remit on average 10% of their earnings to their hometowns. Remittances could potentially lead to trade imbalances. To account for this phenomenon, I assume that, for worker i, born in region o (origin), working in region d (destination), the consumption optimization problem is:

$$\begin{aligned} \max_{C_o,\,C_d} C_{o,d} &= (B_o C_o)^{\lambda} (B_d C_d)^{1-\lambda} \\ \text{s.t. } P_o C_o + P_d C_d &\leq W_d^e z_d(i), \end{aligned} \tag{1}$$

where P_o and P_d are prices for C_o and C_d— the final consumption goods in regions o and d, respectively; B_o and B_d are the amenity values of regions o and d to workers; W_d^e is the nominal wage for each unit of type-e effective labor; and $z_d(i)$ is worker i's productivity in region d. According to this utility function, workers value amenities and consumption in both their hometowns and destinations, with a weight of λ placed on home consumption. Therefore, a λ share of income will be remitted.

Final consumption goods C_o is a bundle of industry final outputs from all four industries:

$$C_o = (C_o^A)^{s_A} (C_o^M)^{s_M} (C_o^S)^{s_S} (C_o^K)^{s_K}, \tag{2}$$

where $s_A + s_M + s_S + s_K = 1$. Let P_o^s be the price of C_o^s, $s \in \{A, M, K, S\}$. Then the price of C_o is

$$P_o = \kappa_p (P_o^A)^{s_A} (P_o^K)^{s_K} (P_o^M)^{s_M} (P_o^S)^{s_S}, \tag{3}$$

where κ_p is a constant. Worker i's indirect utility from the consumption of goods and amenities,

[10] I model migration as driven by idiosyncratic productivity draws and use wage data to discipline the distribution that governs the productivity draws. An alternative is to model migration as driven by idiosyncratic preference shocks.

in both origin and destination is

$$C_{o,d}(W_d^e, z_d, P_o, P_d) = \kappa_c B_o^\lambda B_d^{1-\lambda} \frac{W_d^e z_d(i)}{P_o^\lambda P_d^{1-\lambda}}, \tag{4}$$

where κ_c is a constant.

4.2.2 Migration Decision and Labor Supply Across Regions

Migration is a once-for-life choice. Upon birth, workers learn their draws of productivity in all regions within the country and decide where to work, taking into account their utility from consumption, $C_{o,d}$, and the migration costs they will have to incur. Migration costs, denoted as $d_{o,d}^e$, are both skill-specific and source-destination specific.

Formally, given productivity draws, $\{z_d(i) : d \in \mathbf{G}\}$, worker i chooses the destination d to maximize welfare:

$$U_o(\{W_d^e\}, \{z_d(i)\}, \{P_d\}) = \max_{d\in\mathbf{G}}\{\frac{C_{o,d}(W_d^e, z_d(i), P_o, P_d)}{d_{o,d}^e}\} = \frac{\kappa_c B_o^\lambda}{P_o^\lambda} \max_{d\in\mathbf{G}}\{\frac{W_d^e B_d^{1-\lambda} z_d(i)}{P_d^{1-\lambda} d_{o,d}^e}\} \tag{5}$$

Notice that migration costs enter the utility function only through $\frac{W_d^e}{d_{od}^e}$. Therefore, it can also be interpreted as how workers discount income from the destination. This cost is similar to the iceberg cost assumption used in international trade literature.[11]

For ease of notation, denote $v_d^e = \frac{W_d^e B_d^{1-\lambda}}{P_d^{1-\lambda}}$. Then v_d is the amenity-adjusted real wage *rate* in region d. Worker i will move to region d if and only if this move gives the highest utility:

$$\begin{aligned} \frac{\kappa_c B_o^\lambda}{P_o^\lambda} \frac{v_d^e z_d(i)}{d_{o,d}^e} &\geq \frac{\kappa_c B_o^\lambda}{P_o^\lambda} \frac{v_g^e z_g(i)}{d_{o,g}^e}, \forall g \in \mathbf{G} \\ \Leftrightarrow \frac{v_d^e z_d(i)}{d_{o,d}^e} &\geq \frac{v_g^e z_g(i)}{d_{o,g}^e}, \forall g \in \mathbf{G} \end{aligned} \tag{6}$$

Following Ahlfeldt et al. (2012), I assume $\{z_d(i) : d \in \mathbf{G}\}$ are generated from the Frechet distribution. To capture the individual-specific component in workers' productivity, I allow each worker's draws to be correlated across regions. Specifically, the vector of productivity draws for any given worker is generated from the following CDF:

$$F(z_1(i), z_2(i), ...z_d(i)...) = \exp(-(\sum_{d\in\mathbf{G}} z_d(i)^{-\epsilon_e})^{1-\rho}), \tag{7}$$

[11]The underlying assumption is that the migration cost for any given origin-destination pair is a fixed share of income, regardless of worker i's income or productivity. In reality, of course, migration costs have both fixed and variable components, and I abstract from the fixed costs for tractability.

where ρ controls the inter-regional correlation of productivity draws and ϵ_e controls its cross-sectional dispersion.[12] Under this assumption, the probability that a worker from origin o moves to destination d (derived in Online Appendix A), is:

$$\begin{aligned}\pi^e_{o,d} :&= \mathbf{Pr}(\frac{v^e_d z_d}{d_{o,d}} \geq \frac{v^e_g z_g}{d_{o,g}}, \forall g \in \mathbf{G})\\ &= \mathbf{Pr}(z_d \geq (\frac{v^e_g d_{o,d}}{v^e_d d_{o,g}}) z_g, \forall g \in \mathbf{G})\\ &= \frac{(\frac{v^e_d}{d_{o,d}})^{\epsilon_e}}{\sum_{g\in\mathbf{G}}(\frac{v^e_g}{d_{o,g}})^{\epsilon_e}}.\end{aligned} \tag{8}$$

Let L^e_d denote the *number of workers* with skill level e who are working in d, and let l^e_o denote the number of workers who are born in o. Then $L^e_{o,d} := l^e_o \pi^e_{o,d}$ is the number of workers moving from o to d, and we have the following:

$$L^e_d := \sum_{o\in\mathbf{G}} L^e_{o,d} = \sum_{o\in\mathbf{G}} l^e_o \pi^e_{o,d}. \tag{9}$$

L^e_d is different from the supply of *effective labor units* in region d, due to the self-selection on productivity in migration. To derive the supply of effective labor units, I first derive the expected productivity of migrants from region o to region d, denoted $E(z^e_d | L^e_{o,d})$, in two steps.

In the first step, I derive the expected value of the destination-specific component in workers' indirect utility (5), u^e_o, for workers moving from o to d, denoted $E(u^e_o | L^e_{o,d})$, where $u^e_o := \max_{d\in\mathbf{G}}\{\frac{W^e_d B^{1-\lambda}_d z_d}{P^{1-\lambda}_d d^e_{o,d}}\} = \max_{d\in\mathbf{G}}\{\frac{v^e_d z_d}{d^e_{o,d}}\}$. I show in the appendix that $E(u^e_o | L_{o,d})$ is given by the following expression:

$$E(u^e_o | L^e_{o,d}) = \Phi^{e\frac{1}{\epsilon_e}}_o \Gamma(1 - \frac{1}{\epsilon_e(1-\rho)}), \tag{10}$$

where $\Phi^e_o := \sum_{g\in\mathbf{G}}(\frac{v^e_g}{d^e_{o,g}})^{\epsilon^e}$ measures the welfare of being born in region o. The more connected region o is to other labor markets (smaller $d_{o,g}$), and the more attractive the nearby regions are (higher v^e_g), the higher the utility workers born in region o enjoy.

Notice this expression is independent of d—for workers from the same region, their average utility will be the same regardless of their destination. The intuition is as follows: a destination with higher wages attracts more marginal workers, who obtain lower welfare from the move, pushing down the average utility for the group of workers making the move. This selection along the

[12] Hsieh et al. (2013) also uses this parametric assumption to model individuals' comparative advantage in different occupations. I normalize the mean of the productivity distributions to be the same across regions. Differences in regional productivity enter the economy from the production side.

extensive margin exactly offsets the higher welfare received by the infra-marginal migrants with the same destination, under the parametric assumption of productivity draws. This selection channel is present under more general distributional assumptions, although it might not exactly cancel the effect from infra-marginal migrants.[13]

In the second step, we use $E(u_o^e|L_{o,d}^e)$ to derive $E(z_d^e|L_{o,d}^e)$, the expected productivity of the workers who move from o to d,

$$\begin{aligned} E(z_d^e|L_{o,d}^e) &= E(\frac{u_o^e d_{o,d}^e}{v_d^e}|L_{o,d}^e)(\text{for } L_{o,d}^e,\, u_o^e = \max_{g\in\mathbf{G}}\{\frac{v_g^e z_g}{d_{o,g}^e}\} = \frac{v_d^e z_d}{d_{o,d}}) \\ &= \frac{d_{o,d}^e}{v_d^e} E(u_o^e|L_{o,d}) \\ &= \Phi_o^{e\frac{1}{\epsilon_e}} \Gamma(1 - \frac{1}{\epsilon_e(1-\rho)}) \frac{d_{o,d}^e}{v_d^e} \end{aligned} \tag{11}$$

Let $E_{o,d}^e$ denote the total number of effective labor units, brought to d by workers from o. Then $E_{o,d}^e = E(z_d^e|L_{o,d}^e)L_{o,d}^e = E(z_d^e|L_{o,d}^e) l_o^e \pi_{o,d}^e$. Aggregating over migrants from all origins, the total supply of effective labor units in d, E_d^e, is given by

$$\begin{aligned} E_d^e &= \sum_{o\in\mathbf{G}} E_{o,d}^e \\ &= \sum_{o\in\mathbf{G}} E(z_d^e|L_{o,d}^e) l_o^e \pi_{o,d}^e. \end{aligned} \tag{12}$$

4.2.3 The Distribution of Consumption Expenditures

Workers remit a λ share of income to their hometowns for the purchase of consumption goods. The total remittances sent to location o, by its out-immigrants to location d is then

$$\begin{aligned} R_{o,d}^o &= \sum_{e\in\{h,l\}} L_{o,d}^e E(z_d^e|L_{o,d}^e) W_d^e \lambda \\ &= \sum_{e\in\{h,l\}} E_{o,d}^e W_d^e \lambda \end{aligned} \tag{13}$$

The remaining expenditures, $R_{o,d}^d$, are spent in d:

$$R_{o,d}^d = \sum_{e\in\{h,l\}} E_{o,d}^e W_d^e (1-\lambda). \tag{14}$$

[13]This channel is similar to the selection in trading partner in Eaton and Kortum (2002), in which a country with lower production costs export more marginal goods, and the higher costs of these marginal products offsets the cost advantage of the country. As a result, varieties from different countries have the same average price. See also Hsieh et al. (2013) for the discussion of a similar channel in an occupation-choice context.

The total expenditure on consumption goods in region d is given by

$$R_d = \underbrace{\sum_{o\in\mathbf{G}} R^d_{o,d}}_{\text{Spending from migrants and stayers}} + \underbrace{\sum_{o\in\mathbf{G}} R^d_{d,o}}_{\text{Remittances and spending from stayers}} \tag{15}$$

4.3 Production and Trade

The production side of the economy is a multi-sector version of Eaton and Kortum (2002), extended to incorporate input-output linkages and capital-skill complementarity.

4.3.1 Intermediate Variety Production

Within industry $s, s \in \{A, M, K, S\}$, there is a continuum of intermediate varieties, denoted $\{\omega : \omega \in \Omega_s\}$. Intermediate varieties are produced using industry final outputs and equipped composite labor, both of which are introduced below. In many developing countries, there is segmentation between rural and urban labor markets (Swiecki, 2014). To capture this, I assume intermediate variety producers in urban industries (industries M, K, and S) are located only in urban regions and hire equipped composite labor from urban labor markets; intermediate variety producers in the agricultural industry are located only in rural regions and hire equipped composite labor from rural labor markets.

The production function for intermediate variety ω, in region d, industry s, is

$$\begin{aligned} &y^s_d(\omega) = t^s_d(\omega) a^{s\gamma^A_s}_d(\omega) m^{s\gamma^M_s}_d(\omega) s^{s\gamma^S_s}_d(\omega) l^{s\gamma^L_s}_d(\omega), \\ &s \in \{A\} \text{ if } d \in \mathbf{R}; \quad s \in \{M, K, S\} \text{ if } d \in \mathbf{U}, \end{aligned} \tag{16}$$

where $a^s_d(\omega)$, $m^s_d(\omega)$, and $s^s_d(\omega)$ are the amounts of industry final outputs in agricultural, manufacturing (non-capital), and service industries that are used in production. $l^s_d(\omega)$ is the employment of equipped composite labor. $\gamma^{s'}_s, s, s' \in \{A, M, S, L\}$, are the shares of different inputs in production. $t^s_d(\omega)$ is region d's efficiency in producing variety ω.

Recall that P^s_d is the price of the final outputs of industry s in region d; let W_d be the price for one unit of equipped composite labor in region d. The marginal cost of production is

$$mc^s_d(\omega) = \frac{K_\gamma P^{A\gamma^A_s}_d P^{M\gamma^M_s}_d P^{S\gamma^S_s}_d W_d^{\gamma^L_s}}{t^s_d(\omega)} := \frac{c^s_d}{t^s_d(\omega)}, \tag{17}$$

where K_γ is a constant. c^s_d, introduced for ease of notation, is the marginal cost of ω for producer with unit productivity. The optimal input choice of intermediate variety producers requires

$$\frac{P_o^A a_d^s(\omega)}{y_d^s(\omega) mc_d^s(\omega)} = \gamma_s^A, \frac{P_o^M m_d^s(\omega)}{y_d^s(\omega) mc_d^s(\omega)} = \gamma_s^M, \frac{P_o^S s_d^s(\omega)}{y_d^s(\omega) mc_d^s(\omega)} = \gamma_s^S, \frac{W_d l_d^s(\omega)}{y_d^s(\omega) mc_d^s(\omega)} = \gamma_s^L. \tag{18}$$

4.3.2 Industry Final Goods Production

In each city, there is a representative industry final goods producer in each industry. Industry final goods producers combine intermediate varieties of the same industry into final outputs, to be used for final consumption and the production of intermediate varieties. I assume industry final outputs are non-tradable across cities, but freely tradable between the rural and urban regions *within* each city. Therefore, residents and intermediate variety producers in rural and urban regions of the same city have the same access to industry final goods of all sectors, despite their different specializations in intermediate variety production. The production technology for industry s, region d, is the following:

$$Q_d^s = [\int_{\omega \in \Omega_s} q_d^s(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega]^{\frac{\sigma_s}{\sigma_s - 1}}, s \in \{A\} \text{ if } d \in \mathbf{R}; s \in \{M, K, S\} \text{ if } d \in \mathbf{U}, \tag{19}$$

where is $q_d^s(\omega)$ is the quantity of variety ω used.

4.3.3 Trade in Intermediate Varieties

Intermediate varieties in A, M, and K industries are tradable, both domestically and internationally; intermediate varieties in the service industry are non-tradable.[14] Final goods producers source the intermediate varieties they use from the cheapest source, taking into account trade costs. I further assume markets for intermediate varieties are competitive, so the producers of intermediate varieties sell their products at marginal costs. Region d's price of intermediate variety ω, produced in another region d' is

$$p_{d,d'}^s(\omega) = mc_{d'}^s(\omega)\tau_{d,d'}, \tag{20}$$

where $\tau_{d,d'}$, the iceberg trade cost, is the amount of goods needed to be shipped by producers in d' for one unit to arrive at d. The price for variety ω that a producer in region d actually pays is the cheapest price among all sources:

$$p_d^s(\omega) = \min_{d'}\{p_{d,d'}^s(\omega)\} = \min_{d'}\{\frac{c_{d'}^s}{t_{d'}^s(\omega)}\tau_{d,d'}\}. \tag{21}$$

As in Eaton and Kortum (2002), I assume $\{t_d^s(\omega) : \omega \in \Omega_s\}$ are generated from the Frechet

[14] In the following, I assume trade costs are infinite for intermediate varieties in the service industry, and proceed as if service was tradable.

distribution with location parameter T_d^s and dispersion parameter θ, with the following CDF:

$$F_d^s(t) = \exp(-\mathrm{T}_d^s t^{-\theta}). \tag{22}$$

Under this distribution, among the expenditures spent on intermediate varieties in region d, industry s, the share allocated to varieties produced in region d' is

$$\delta_{d,d'}^s = \frac{T_{d'}^s (c_{d'}^s \tau_{d,d'})^{-\theta}}{\sum_{d''} T_{d''}^s (c_{d''}^s \tau_{d,d''})^{-\theta}}, \tag{23}$$

where the denominator sums over all urban regions if $s \in \{M, K, S\}$, that is, if s indexes an urban industry, and over all rural regions if $s \in \{A\}$.

The parametric assumption on productivity also implies that region d's distribution of prices for intermediate varieties in industry s is

$$F_d^s(p) = 1 - \exp(-\Psi_d^s p^{-\theta}), \tag{24}$$

where $\Psi_d^s = \sum_{d'} T_{d'}^s (c_{d'}^s \tau_{d,d'})^{-\theta}$. Again, the summation is taken over urban regions for urban industries, and over rural regions for the agricultural industry. The unit price for industry final goods corresponding to production function (19) is

$$\begin{aligned} P_d^s &= [\int_0^\infty p_d^{s\,1-\sigma_s} dF_d^s(p)]^{\frac{1}{1-\sigma_s}} \\ &= [\Gamma(\frac{\theta + 1 - \sigma_s}{\theta})]^{\frac{1}{1-\sigma_s}} (\Psi_d^s)^{-\frac{1}{\theta}}. \end{aligned} \tag{25}$$

4.3.4 Equipped Composite Labor Production

Equipped composite labor is produced by a representative producer in each region, from capital and two types of labor units. I incorporate capital-skill complementarity by specifying the production function of equipped composite labor in a nested CES form, with capital being complementary to high-skill labor, and substitutable to low-skill labor.[15]

Formally, effective high-skill labor units, E_d^h, low-skill labor units, E_d^l, and capital and equipment, K_d, are combined into *equipped composite labor*, E_d, through the following technology:

$$E_d^{eh} = [(1 - \eta_d^h)^{\frac{1}{\rho_{kh}}} (K_d)^{\frac{\rho_{kh}-1}{\rho_{kh}}} + (\eta_d^h)^{\frac{1}{\rho_{kh}}} (E_d^h)^{\frac{\rho_{kh}-1}{\rho_{kh}}}]^{\frac{\rho_{kh}}{\rho_{kh}-1}} \tag{26}$$

[15] This formulation has a tradition in macroeconomics (see, for example Krusell et al., 2000), and has recently been adapted to the international setting to examine impacts of globalization on wage inequality by Burstein et al. (2013) and Parro (2013).

$$E_d = [(1-\eta_d^l)^{\frac{1}{\rho_{lkh}}}(E_d^l)^{\frac{\rho_{lkh}-1}{\rho_{lkh}}} + (\eta_d^l)^{\frac{1}{\rho_{lkh}}}(E_d^{eh})^{\frac{\rho_{lkh}-1}{\rho_{lkh}}}]^{\frac{\rho_{lkh}}{\rho_{lkh}-1}}, \tag{27}$$

where E_d^{eh} is *equipped high-skill labor*, the output from the inner nest. ρ_{kh} ($\rho_{kh} < 1$) is the elasticity of substitution between high-skill labor and capital, and ρ_{lkh} ($\rho_{lkh} > 1$) is the elasticity of substitution between equipped high-skill labor and low-skill labor. η_d^h and η_d^l determine the region-specific shares of different factors in equipped composite labor.

Let W_d^h/W_d^l be the wage rate for high-/low-skill labor, W_d^{eh} the unit price for equipped high-skill labor, and W_d the unit price for equipped composite labor. The optimization decision and the zero-profit conditions of equipped composite labor production imply the following:

$$\begin{aligned} W_d^{eh} &= [(1-\eta_d^h)(P_d^K)^{1-\rho_{kh}} + (\eta_d^h)(W_d^h)^{1-\rho_{kh}}]^{\frac{1}{1-\rho_{kh}}} \\ W_d &= [(1-\eta_d^l)(W_d^l)^{1-\rho_{lkh}} + (\eta_d^l)(W_d^{eh})^{1-\rho_{lkh}}]^{\frac{1}{1-\rho_{lkh}}} \end{aligned} \tag{28}$$

$$\begin{aligned} \frac{P_d^K K_d}{W_d^h E_d^h} &= (\frac{P_d^K}{W_d^h})^{1-\rho_{kh}} \frac{1-\eta_d^h}{\eta_d^h} \\ \frac{W_d^{eh} E_d^{eh}}{W_d^l E_d^l} &= (\frac{W_d^{eh}}{W_d^l})^{1-\rho_{lkh}} \frac{1-\eta_d^l}{\eta_d^l} \end{aligned} \tag{29}$$

Equation (29) expresses the ratios between the shares of different factors in equipped composite labor as functions of relative prices and technological parameters, η_d^h and η_d^l. Factors' shares vary by regions and prices. Nonetheless, to simplify notation, I use β_d^K, β_d^h, and β_d^l to denote the shares of capital, high-, and low-skill labor in equipped composite labor in region d:

$$\beta_d^K + \beta_d^h + \beta_d^l = 1. \tag{30}$$

4.3.5 Goods and Labor Markets Clearing Conditions

Let X_d^s be region d's production of final outputs in industry s. Since final output producers add no value in converting intermediate varieties into industry final outputs, X_d^s is also the value of their input demand for intermediate varieties. The total demand for the intermediate varieties in industry s , produced in region d, is:

$$\begin{aligned} D_d^s &= \sum_{d' \in \{\mathbf{U}\}} X_{d'}^s \delta_{d',d}^s, s \in \{M, K, S\} \\ D_d^s &= \sum_{d' \in \{\mathbf{R}\}} X_{d'}^s \delta_{d',d}^s, s \in \{A\}. \end{aligned} \tag{31}$$

To produce D_d^s amount of intermediate varieties in industry s, the producers in region d use, respectively, $D_d^s\gamma_s^A, D_d^s\gamma_s^M,$ and $D_d^s\gamma_s^S$ amounts of the industry final outputs of agricultural, manufacturing, and service industries. The producers also employee $D_d^s\gamma_s^L$ worth of the equipped composite labor, whose income will be distributed to capital and workers. The labor market clearing conditions, which are different for rural and urban labor markets in each city, are

$$\begin{aligned}&\text{Rural (d}\in \mathbf{R}\text{)}: E_d^h W_d^h = D_d^A\gamma_A^L\beta_d^h; \quad E_d^l W_d^l = D_d^A\gamma_A^L\beta_d^l,\\ &\text{Urban (d}\in \mathbf{U}\text{)}: E_d^h W_d^h = \beta_d^h \sum_{s\in\{M,K,S\}} D_d^s\gamma_s^L; \quad E_d^l W_d^l = \beta_d^l \sum_{s\in\{M,K,S\}} D_d^s\gamma_s^L.\end{aligned} \tag{32}$$

The demand for industry final outputs in each region comprises demand from residents and intermediate variety producers. Since residents and producers in both the rural region and the urban region of a city purchase industry final outputs from the same representative producer in that city, to express market clearing conditions for industry final goods, I use d to denote an urban region, and d' to denote the rural region of the same city. The market clearing conditions for industry final outputs are:

$$\begin{aligned}X_{d'}^A &= (C_d^A + C_{d'}^A) + D_{d'}^A\gamma_A^A + \sum_{s\in\{M,K,S\}} D_d^s\gamma_s^A, \quad d'\in \mathbf{R}\\ X_d^M &= (C_d^M + C_{d'}^M) + D_{d'}^A\gamma_A^M + \sum_{s\in\{M,K,S\}} D_d^s\gamma_s^M, \quad d\in \mathbf{U}\\ X_d^S &= (C_d^S + C_{d'}^S) + D_{d'}^A\gamma_A^S + \sum_{s\in\{M,K,S\}} D_d^s\gamma_s^S, \quad d\in \mathbf{U}\\ X_d^K &= (C_d^K + C_{d'}^K) + D_{d'}^A\gamma_A^L\beta_{d'}^K + \sum_{s\in\{M,K,S\}} D_d^s\gamma_s^L\beta_d^K. \quad d\in \mathbf{U}\end{aligned} \tag{33}$$

In Equation (33), the left side is the total supply of industry final outputs in the city; on the right side, $D_{d'}^A\gamma_A^{s'}$ and $\sum_{s\in\{M,K,S\}} D_d^s\gamma_s^{s'}$ are the demands from intermediate variety producers in the agricultural industry and the three urban industries, respectively; $C_d^s + C_{d'}^s$ is the sum of consumption demands in rural and urban regions of the city. The consumption demand term is calculated as $s_s[R_d + R_{d'} - (S_d + S_{d'})]$, where R_d is region d's aggregate income, remittances included; $S_d + S_{d'}$ is the city's international trade surplus taken as exogenous from the data, scaled to the model economy;[16] and s_s is the share of industry s in the final consumption bundle. Adjusting for trade surpluses ensures the calibration of regional productivity takes into account the international trade imbalances, about 5% of the GDP of China in 2005. After calibration, however, in all counterfactual experiments, I focus on the competitive equilibrium defined below, without international trade imbalances (but allowing for intra-national imbalances arising from remittances).

[16] I provide details on the construction of city-level surpluses in Online Appendix B.

4.4 Definition of Equilibrium

The parameters in the economy are the following: preference parameters, including $\{\sigma_A, \sigma_M, \sigma_K\}$ $\{s_A, s_M, s_K, s_S\}$, and λ; spatial frictions, including migration costs $\{d_{o,d}\}$ and trade costs $\{\tau_{o,d}\}$; production technology, including $\{\gamma_s^{s'}\}$, $\{\eta_d\}$, $\{\rho_{ks}, \rho_{lks}\}$, and θ; local productivity and amenities, $\{T_d^s\}$ and $\{B_d^e\}$; and initial labor endowments in each region, $\{l_o^e\}$.

Definition 1 *A competitive equilibrium of the economy is defined as a set of prices and allocations that satisfy the following conditions:*

1. *Workers' migration decisions are optimal, that is, Equation (6) is satisfied. In aggregate, this implies Equation (8).*
2. *The distribution of effective labor units E_d^e, and final consumption expenditures, R_d, are consistent with workers' migration choices—Equations (12) and (15).*
3. *The decisions of intermediate variety producers are optimal—Equations (17) and (18).*
4. *The decisions of composite labor producers are optimal—Equations (28) and (29).*
5. *Industry final goods producers' production and sourcing decisions are optimal—Equations (23) and (25).*
6. *Workers' consumption decisions are optimal.*
7. *Labor markets and goods markets clear—Equations (31)-(33).*

The definition of the equilibrium also highlights the key departure from the existing applications of similar quantitative trade models in cross-country settings: exogenous labor supply is replaced with migration decisions, summarized by Equation (8), so the distribution of labor across regions is endogenous.

5 Data Descriptions

Quantifying the model primarily requires the following information: to calibrate regional productivity, we need, by skill level, the average wage in each region, and the employment for each city-industry pair; to calibrate region-specific parameters in equipped composite labor production function, we need the shares of different factors in equipped composite labor; to estimate domestic migration costs we need migration flows; to estimate trade costs we need information on domestic trade flows; to determine the production function of equipped composite labor, we need the factor shares of its inputs in each region; finally we need the measures of geographic and cultural distances between regions. This section describes briefly the sources of data; Online Appendix B provides more details.

I use the 2005 mini population census to estimate the wage rates for Chinese regions. I estimate the average wage for unskilled workers and the skill premium in each region as the regional fixed effects and the region-specific skill dummies, in an individual wage regression that controls for a rich set of individual demographic and occupation variables. This regression approach nets out the differences in demographics and detailed industry structures across regions, which are not explicitly modeled. The specification and the results of this regression are reported in the appendix.

I also use the 2005 mini census to construct the *number of workers* employed in each city-industry. Once we have the estimates for migration costs and regional amenity-adjusted real wages, we can use Equation (12) to convert the number of workers into the employment of *effective labor units*. Combining this with the regional wages estimated above, I obtain the total wage bill for high- and low-skill workers at the city-industry level.[17]

Using the data constructed in the preceding paragraphs, we can readily compute the relative shares of wage payments to high- and low-skill workers. Determining η_d^h and η_d^l, the region-specific parameters in equipped composite labor production function, further requires the relative shares between capital and equipment (K) and labor. For the urban sector, I use the 2004 Annual Survey of Industrial Production to construct wage bill and capital expenditures for each city, which I combine with the relative shares of skilled over unskilled workers, to obtain the shares for all three inputs into equipped composite labor;[18] for the rural sector, due to the lack of regional data, I assume all cities have the same capital/labor share, and determine this share using the national input-output table.

To construct a database of inter-regional and inter-sectoral migration, I use the 2000 population census. The 2000 census serves the purpose best because it reports birthplace information, which is essential for the definition of migration, a lifetime decision in the theoretical framework.[19] For each worker, I identify his or her skill level, current city, birth province, type of Hukou, and whether he or she is currently working in a rural or urban industry, and then determine his or her migration status based on this information.[20]

[17]We run into a small sample problem and end up with zeros for the employment capital and equipment industry in some cities, as my sample is only a 1% sub-sample of the mini-census. To overcome this problem, I tabulate employments, differentiating only between agricultural and urban industries, even though the data contains employment by two-digit industry. (As a result, we do not know the distribution of employments across the three urban industries in each city.) I supplement this information with the ratio of employment in industry K over industry M, constructed from the manufacturing sub-sample of the 2004 economic census, to obtain the employment information at the city-industry level. I provide more details in the online appendix.

[18]This is an annual firm-level survey, containing detailed financial information for all state-owned enterprises, as well as private firms with sales over 5 million RMB yuan, in the industrial sector. I aggregate firm-level expenditures on capital and equipment and labor to compute the city-specific labor share in equipped composite labor.

[19]The 2005 mini population census, on the other hand, reports only migration information during the past 5 years and, therefore, is inconsistent with the notation of long-term migration adopted here. We cannot combine 5-year migration with long-term migration constructed from the 2000 census, because of the possibility of repeat migrants or return migrants.

[20]Hukou is the household registration system in China, which records the place of legal residence and the sector

I construct proxies for geographic distance and cultural distance between Chinese cities. For any two cities, their geographic distance is calculated as the greater-circle distance between the coordinates of their city centers, proxied by the locations of their local governments, extracted from Google Maps. The cultural distance is constructed as $1 - \text{corr}(V_o, V_d)$, where V_o is a vector, the elements of which are the shares of various ethnic groups in the total ethnic minority population in o in the 1990 census: the cultural distance between two cities is small if two cities had similar compositions of ethnic minorities in the 1990s.[21]

Finally, I use the 2002 inter-regional input-output table of China to construct trade flows between Chinese provinces, which are then used for the estimation of domestic trade costs.

6 Parameterization

Before conducting counterfactual experiments, I calibrate the model to the 2005 equilibrium.[22] This section explains how I determine the parameters in the model, starting with the parameters that are calibrated independently.

6.1 Parameters Calibrated Independently

The dispersion parameter, ϵ_e, governs the variance of the idiosyncratic component of workers' productivity draws. The parametric assumption in Equation (7) implies that, the wage distribution of workers *staying* in their hometowns follows a Frechet distribution with dispersion parameter $(1-\rho)\epsilon_e$ (proved in the appendix). A property of the Frechet distribution is that its coefficient of variations satisfies the following relationship:

$$\frac{\text{Variance}}{\text{Mean}^2} = \frac{\Gamma(1 - \frac{2}{\epsilon_e(1-\rho)})}{(\Gamma(1 - \frac{1}{\epsilon_e(1-\rho)}))^2} - 1. \tag{34}$$

Guided by this relationship, I use the wage distribution of *stayers* to recover $\epsilon_e(1-\rho)$.[23] Specif-

of origin for Chinese residents; the information on birth place is only up to the provincial level in the census, so I tabulate only the source province for migrants. The census does record the source city of the most recent migration move for each individual. That city, however, is not necessarily the same as an individual's birth city, as he or she may be a repeat migrant. In Online Appendix B, I provide additional background information on the Hukou system and a discussion of the drawbacks of alternative ways of constructing migration flows.

[21] Migrations were less common prior to 1990; therefore correlation constructed this way captures the historical cultural distance between regions, and is unlikely to be driven by current migration. I provide background information on ethnicity in China and the summary statistics of cultural distance in the appendix.

[22] An alternative is to solve the model in changes, as in Dekle et al. (2008). This alternative is infeasible because the level of aggregation in migration and trade are different, between the model and the data. An additional advantage of calibrating the benchmark equilibrium rather than solving the model in changes is that we can assess the fit of the model by looking at moments that are not direct targets of calibration.

[23] Hsieh et al. (2013) also uses this relationship to recover the ability dispersion and follows a similar strategy,

ically, I regress the log wage of stayers on regional fixed effects, individual demographics, and industry fixed effects, for high- and low-skill worker samples separately. I then take the exponents of the residuals, compute their coefficients of variations, and choose $\epsilon_e(1-\rho)$ so that Equation (34) gives the same value. This procedure determines $\epsilon^{\mathrm{h}}(1-\rho) = 2.72$ and $\epsilon^{\mathrm{l}}(1-\rho) = 2.88$. By deriving statistics for only stayers' wage distribution, and matching them to their data counterparts, this procedure takes into account the self-selection on productivity in migration.[24]

The parameter ρ controls the correlation of individuals' productivity draws across regions. My strategy for calibrating it is first to compute the explanatory power of individual fixed effects in an individual-panel wage regression using real data. Then I choose ρ so that, in the simulated data, individual fixed effects have the same level of explanatory power. This procedure determines ρ to be 0.4. In the appendix I provide more details on this procedure.

Productivity dispersion in intermediate variety, θ, is not separately identifiable from trade costs using the data I have. I assign a value of 4, the preferred estimate of Simonovska and Waugh (2011), to the productivity dispersion for A, M, and K industries.[25] The elasticities of substitution between high-skill labor and capital, and between low-skill labor and equipped high-skill labor, are set to the estimates in Krusell et al. (2000)—0.67 and 1.67, respectively.[26] These values imply that capital and high-skill labor are complements, and both are substitutes to low-skill labor.

The share of remittances in migrants' income is calibrated to 10%, following Akay et al. (2012). The shares of different industries in the final consumption bundle, $\{s_A, s_M, s_K, s_S\}$, are calibrated to the shares of these industries in final consumption. The calibration determines $s_A = 0.23, s_M = 0.24, s_K = 0.01, s_S = 0.52$. The shares of different inputs in intermediate variety production, $\{\gamma_s^{s'}\}$, are calibrated to the 2002 national input-output table.

The upper panel of Table (2) summarizes the sources and values of these parameters. The lower panel provides information on other parameters, which I discuss in the rest of this section.

described below, to calibrate ρ in an occupation-choice model.

[24]We can also use migrants for this calibration. In that case, the model predicts that, only for migrants sharing the same origin *and* destination, will the wage distribution follow a Frechet distribution. This approach is infeasible for two reasons: first, in the data, we identify the source region only up to the provincial level, and second, for many origin-destination pairs, there are only a few workers.

[25]Simonovska and Waugh (2011) focuses on aggregate trade flows. Papers focusing on agricultural trade alone, for example, Donaldson (Forthcoming) and Sotelo (2014), report similar estimates for the elasticity of trade. In this model, trade is driven by Ricardian comparative advantage, so the love-for-variety parameters do not have impacts on the levels and elasticities of trade; they are used solely for computing the aggregate price indices, and the only requirement is that $\theta - \sigma > 1$, so that the price indices are integrable.

[26]Parro (2013) and Burstein et al. (2013) use the same parameter values when examining the roles of skill-biased technological change and globalization in explaining the rise in the skill premium.

Table 2: Model Parameterization

A: Parameters Calibrated Independently

Parameter	Description	Target/Source	Value
ρ	Correlation in worker productivity draws	Idiosyncratic component of individual wage	0.4
ϵ^h,ϵ^l	Dispersion in worker productivity draws	Equation (34)	$\epsilon^h = \frac{2.73}{1-\rho}$, $\epsilon^l = \frac{2.88}{1-\rho}$
θ	Elasticity of trade	Simonovska and Waugh (2011)	4
λ	Share of remittances	Akay et al. (2012)	0.1
ρ_{kh}, ρ_{lkh}	Elasticities in equipped composite labor	Krusell et al. (2000)	$\rho_{kh} = 0.67$, $\rho_{lkh} = 1.67$
s_A, s_M, s_S, s_K	Sectoral shares in final consumption	Aggregate consumption in the economy	$s_A = 0.22, s_M = 0.24$ $s_S = 0.52, s_K = 0.01$
$\gamma_s^{s'}$	Input-output linkages	National input-output table	See Appendix B.4

B: Parameters Estimates/Calibrated in Equilibrium

Parameter	Description	Target/Source	Value
$\{d_{o,d}\}$	Migration Costs	Migration Flow	See Table(3)
$\{\tau_{o,d}\}$	Domestic Trade Costs	Domestic Trade Flow	See Table(4)
t_a, t_m, t_k	International Trade Costs	International Openness	See Table(4)
$\{\eta_d^h\}$, $\{\eta_d^e\}$	Factor weights in equipped composite labor	Corresponding factor shares in the data	-

6.2 Migration Cost Estimation

6.2.1 The Specification of Migration Cost

I specify the cost of a migration move from o to d as

$$\ln(d^e_{o,d}) = \beta^e_1 I_1 + \beta^e_2 * I_1 * \text{dist}_{o,d} + \beta^e_3 I_2 + \beta^e_4 * I_2 * \text{dist}_{o,d} + \beta^e_5 I_3 + \beta^e_6 * I_3 * \text{dist}_{o,d} + \beta^e_7 * I_4 + \beta^e_8 * \text{Cdist}_{o,d}, \tag{35}$$

where I_1-I_4 are mutually exclusive dummy variables: I_1 indicates if o and d belong to different cities within the same province; I_2 indicates if o and d belong to different provinces within the same large region (of which there are seven in China, each containing five provinces on average); I_3 indicates if o and d belong to different large regions. I_4 is the indicator for rural-urban migration. These dummy variables capture different kinds of institutional barriers to the free mobility of labor. $\text{dist}_{o,d}$ is the geographic (great-circle) distance between o and d, while $Cdist_{o,d}$ is the cultural distance: these two variables capture the geographic and cultural barriers to migration.

6.2.2 Estimation Strategy

If, in the data, migration flow is recorded at the city-to-city level, both migration cost parameters, $\{\beta\}$, and amenity-adjusted real wages, $\{v^e_d\}$, can be estimated in linear regression. In this section, I use this simpler case to illustrate the source of identification; as discussed in the data section, however, the migration data is recorded at province-to-city level, so in actual implementation, I use non-linear least squares and estimate the parameters by minimizing the distance between the data and the model-predicted province-to-city flows. I provide the details on estimation in the online appendix.

From Equation (8), if we divide $\pi_{o,d}$ by $\pi_{o,o}$, the resulting equation is:

$$\ln\left(\frac{\pi_{o,d}}{\pi_{o,o}}\right) = \underbrace{\epsilon^e}_{\text{Ability Dispersion}} \left[\underbrace{\ln(v^e_d) - \ln(v^e_o)}_{\text{Fixed Effects}} - \underbrace{\ln d_{o,o}}_{0} + \underbrace{\ln d_{o,d}}_{\text{Migration Cost}}\right] \tag{36}$$

We can then substitute Equation (35) into the migration costs component in the expression, and estimate this specification using linear regression. The specification demonstrates clearly that the dispersion of workers' productivity, ϵ^e, is not separately identifiable from migration costs, and therefore I calibrate it using information on wage dispersion. Parameters governing migration costs, $\{\beta\}$, are identified from within variation; if, within a region, the majority of workers are from regions that are far away, the estimated migration costs will be small. The logs of the amenity-adjusted real wages, v^e_d and v^e_o, are identified as destination and origin fixed effects; intuitively, if a region employees a larger number of workers (relative to the number of workers born in the region), it either pays a good wage, or offers attractive amenities. Once we calibrate the remaining parameters in the benchmark economy and solve the model, we can back out amenities, B^e_d, by subtracting wages and prices from v^e_d.[27]

6.3 Calibrating the Rest of the World

With the estimated migration costs and $\{v^e_d\}$, Equation (12) predicts the supply of effective labor in each place. Together with the regional wage estimated before, I compute the regional and, in turn, the national labor value added in China. I then use the share of Chinese value added in the world, calculated from Penn World Table 6.1, to determine the GDP of the ROW:

$$\text{GDP}_{\text{ROW}} = \text{GDP}_{\text{China}} * \frac{\text{Data GDP}_{\text{ROW}}}{\text{Data GDP}_{\text{China}}} \tag{37}$$

To calibrate the total number of effective labor units available in the ROW, I assume that $E_{\text{ROW}} = E_{\text{China}} \frac{\text{Population}_{\text{ROW}}}{\text{Population}_{\text{China}}}$, where E stands for number of effective labor units.[28] The wage for each effective labor unit in the ROW is then $\frac{\text{GDP}_{\text{ROW}}}{E_{\text{ROW}}}$.

6.4 Joint Estimation of Trade Costs and Regional Productivity

6.4.1 The Specification of Trade Cost

Following the gravity literature in international trade, I specify the trade costs between any two regions *within* China as a log linear function of the geographic, institutional and cultural distance between them:

$$\log(\tau_{o,d}) = \gamma_1 I'_1 + \gamma_2 * (1 - I'_2 - I'_3) * \text{dist}_{o,d} + \gamma_3 I'_2 + \gamma_4 * I'_2 * \text{dist}_{o,d} + \gamma_5 I'_3 + \gamma_6 * I'_3 * \text{dist}_{o,d} + \gamma_7 * I'_4 + \gamma_8 * \text{Cdist}_{o,d} \tag{38}$$

Dummy variables I'_1-I'_3 in this specification are the same as I_1-I_3 in the migration cost spec-

[27] Note that I use the 2000 data to estimate the long-run migration costs; the wage and employment data, on the other hand, represents the 2005 economy. To ensure that the recovered $\{v^e_d\}$ are consistent with the 2005 employment distribution, after estimating $\{\beta\}$, I use workers' birthplace and employment distribution in 2005, and solve the migration model again. Specifically, I solve for $\{v^e_d\}$, so that the model-predicted total number of workers in each region is the same as that in data for the year of 2005, i.e., $\sum_{o\in\mathbf{G}} l^e_o \pi^e_{o,d} = \sum_{p\in P} L^e_{p,d}$, where $L^e_{p,d}$ (data) is numbers of workers working in region d; l^e_o (data) is the number of workers born in region o; and $\pi^e_{o,d}$ is the model-predicted probability of migration, as functions of $\{v^e_d\}$. The workers employment distribution in 2005 comes from the 2005 mini census directly. Because the 2005 mini census does not provide birthplace information, I construct the birthplace distribution using the 2000 census, focusing on appropriately adjusted age groups. Online Appendix B provides more details. One additional benefit of updating $\{v^e_d\}$ is that, even if there are changes in migration costs during the period 2000–2005, our benchmark calibration still ensures that the number of workers in each place is the same as that in the data.

[28] I assume that in the ROW, intermediate varieties are produced using industry final outputs and effective labor units directly, without equipped composite labor, so there is neither the distinction between skilled and unskilled workers nor capital-skill complementarity.

ification.[29] I'_4 is an indicator for common provincial border. $\text{Cdist}_{o,d}$ and $\text{dist}_{o,d}$ are also defined in the same way as in the migration cost specification, except that here I allow for positive trade costs within the same city—$\text{dist}_{o,o} > 0$. I proxy within-city distance, $\text{dist}_{o,o}$, using city o's radius, constructed as half of city o's average distance to its five closest neighboring cities.

I further specify the trade cost between a given Chinese city and the ROW as the trade cost between that Chinese city and its nearest port city, plus a parameter for international trade cost that captures tariffs, non-tariff barriers, and information flow costs, among other barriers to trade. These costs likely differ across industries, so I allow international trade costs to be industry-specific, too. The international trade costs will be calibrated to match industry trade openness in China in 2005. The targets for industry openness are reported in Panel B of Table (4).

6.4.2 Estimation Strategy

Similar to the migration cost estimation, if we have city-pair trade flow data, we can estimate the specification using a linear regression. For the clarity of exposition, in this section, I focus on this simple setup to illustrate the sources of identification in estimation. I provide more details on the actual computational algorithm in the online appendix, in which, to accommodate the aggregate nature of the trade data, I jointly determine trade costs and region-specific productivity, by solving the full model and choosing the parameters, so that the distance between the model-predicted trade flows and the data is minimized.

From Equation (23) we can derive the following equation:

$$\begin{aligned}\ln\left(\frac{\delta^j_{d,o}}{\delta^j_{d,d}}\right) = \underbrace{-\theta}_{\text{Trade Elasticity}} & \underbrace{\left[\left(\frac{1}{\theta}\ln(T^j_d) - \ln(c^j_d)\right) - \left(\frac{1}{\theta}\ln(T^j_o) - \ln(c^j_o)\right)\right.}_{\text{Fixed Effects}} \\ - & \left.\underbrace{\ln\tau_{o,o}}_{\text{Trade Cost (within city)}} + \underbrace{\ln\tau_{o,d}}_{\text{Trade Cost}}\right].\end{aligned} \tag{39}$$

We can then obtain the estimation specification by substituting Equation (38) into trade cost in this equation. Applying this specification to domestic trade flow data, we can estimate $\ln(\frac{{T^j_d}^{\frac{1}{\theta}}}{c^j_d})$, the cost-adjusted productivity, with origin and destination fixed effects. Intuitively, if region d purchases a lot from local producers (large $\delta^j_{d,d}$), region d is either very productive in converting input bundle into output, or it has access to cheap input bundles, both of which imply large $\ln(\frac{{T^j_d}^{\frac{1}{\theta}}}{c^j_d})$. We can also recover $\{\gamma\}$, the coefficients determining domestic trade costs, where the source of identification comes from the extent to which region d sources from regions that are at different

[29] Under this specification, the marginal impact of within-city distance on trade cost is γ_2, the same as that of between-city, within-province distance. I also try treating these two variables separately, and it seems the data does not allow for simultaneous identification of these two variables.

distances.[30]

Once we have the estimates, $\widehat{\ln(\frac{T_d^{j\,\frac{1}{\theta}}}{c_d^j})}$, we can use the model structure to separate T_d^j and c_d^j and to calibrate the industry-level international trade costs. Note that c_d^j depends on local wages and the prices of industry final outputs, which in turn depend on productivity and wages in all regions in the economy. Therefore, fixing wages at the observed value, for any given level of industry trade barriers, we can choose a distribution of $\{T_d^j\}$ such that, given wages and productivity across regions, the equilibrium distribution of costs $\{c_d^j\}$ from the trade model satisfy that $\ln(\frac{T_d^{j\,\frac{1}{\theta}}}{c_d^j}) = \widehat{\ln(\frac{T_d^{j\,\frac{1}{\theta}}}{c_d^j})}$. We can then determine the international trade costs so that the model exhibits the same level of international trade openness as in the data.

6.5 Estimation Results

6.5.1 Migration Costs

Table (3) reports the estimates for the migration costs. The model fits the data well, as indicated by the high R^2s. The signs of coefficients are as expected: all measures of distance increase migration costs. In terms of magnitude, the cost of migrating to other cities within the same province is around 117 log points for both types of workers. As a migration move covers more distance, it incurs a larger cost: for skilled workers, the additional cost of crossing a provincial border is about 30 log points, and the additional cost of crossing a regional border is another 20 log points; these costs are slightly higher for unskilled workers.

The continuous components of geographic distance have nonlinear effects on migration costs: when the origin and the destination are in the same province, the marginal cost of moving an extra 1000 kilometers is not significant; when the origin and destination are in different provinces within the same large region, the marginal cost is sizable and statistically significant; when the origin and destination are in different large regions, the marginal cost becomes somewhat smaller, but is still significant. This pattern holds for both types of workers, but the coefficients are much larger for unskilled workers.

The estimation also reveals substantial costs, about 60 log points, associated with rural-urban migration. This magnitude, however, is only about one-third of the calibrated "labor wedge" for

[30] Since I actually implement the estimation using provincial-level trade data, the identification of the two variables that vary only within a province, the inter-city dummy and the within-provincial geographic distance, relies on differences in trade patterns for provinces with different internal structures. Intuitively, the larger these coefficients are, the higher the within-province trade costs are and the more intensive the inter-provincial trade is. Suppose a province trades intensively with itself. All else equal, if this province has many cities, then its low trade-penetration rate will be reflected in a large estimate for the intercity dummy; if, on the other hand, this province has only a small number of (geographically) large cities, then the low trade-penetration rate will be reflected in a large estimate for the coefficient for within-province distance.

Table 3: Estimates of Migration Costs

	Skilled Workers	Unskilled Workers
I(Different Cities, Same Province)	1.167	1.192
	(0.0492)	(0.043)
I(Different Provinces, Same Region)	1.502	1.555
	(0.0318)	(0.03)
I(Different Regions)	1.719	1.812
	(0.0275)	(0.0305)
I(Rural to Urban)	0.586	0.606
	(0.0191)	(0.0172)
I(Different Cities, Same Province)*Distance	0.378	0.332
	(0.2761)	(0.1984)
I(Different Provinces, Same Area)*Distance	0.367	0.738
	(0.0578)	(0.048)
I(Different Regions)* Distance	0.215	0.539
	(0.0225)	(0.0292)
Cultural Distance	0.141	0.148
	(0.0312)	(0.0359)
Observations	42160	42160
R^2	0.92	0.67

Notes: This table reports the estimates of domestic migration costs. Robust standard errors are in parentheses. *Distance* is measured as the great circle distance between cities (in 1000 km); *Cultural Distance* is measured as one minus the correlation in lagged ethnic minority shares between cities.

China in Swiecki (2014). The difference underscores the importance of accounting for the geographic dimension: a large proportion of the measured rural-urban wedge could be a joint product of regional inequality and spatial frictions.

Finally, for both types of workers, the coefficients for cultural distance are positive and significant. The standard deviation of cultural distance is 0.3, so increasing cultural distance by one standard deviation leads to an increase of around 5 log points in migration costs.

6.5.2 Trade Costs

Panel A in Table (4) presents the estimates for domestic trade costs. The model fits the data well, with an R^2 of 0.7. According to the estimates, crossing a provincial border increases trade costs by about 100 log points; crossing a regional border adds another 20 log points; sharing a common provincial border, on the other hand, could reduce the costs by 6.5 log points. If the dummies variables indeed capture the institutional barriers to domestic trade, the estimates indicate large institutional barriers to trade.

Geographic distance significantly increases trade costs: for trading partners from different provinces within the same large region, distance has a large impact—each additional 1000 kilometers increases trade costs by 18 log points; for trading partners from two different regions, the impacts of distance are smaller: each additional 1000 kilometers increases trade costs by 8 log points. Cultural distance does not appear to affect trade costs. Perhaps due to the lack of variation in the number of cities *within* a province, and the radiuses of these cities, the estimation does not identify any trade costs associated with crossing city borders, or with additional kilometers between cities within the same province.

Overall, the estimates suggest, the trade costs between cities within China increase with both institutional and geographic distances. The former, captured by dummy variables in the regression, plays a more important role, especially for close trade partners. The size of the inter-provincial dummy is smaller than in studies examining market fragmentation in China using earlier data (Poncet, 2005; Poncet, 2003). On the other hand, relative to comparable estimates for the U.S. (Wolf, 2000; Crafts and Klein, 2014), my estimate of the provincial-border effect is about twice as large, reflecting larger barriers to trade flows at provincial border in China. Since my estimates use variation in province-level trade costs, one valid concern is whether, due to the aggregate nature of the data, I might misattribute the cost of trading within a province to provincial borders. If that is the case, a further concern is whether the results from counterfactual experiments would be affected. In the appendix, I discuss related issues arising in the literature focusing on U.S. and perform a robustness exercise, in which I decrease the provincial border dummy in the economy to the U.S. level while increasing the coefficients for continuous distance components, keeping the overall level of domestic trade costs the same. All of the results are robust to this alternative

Table 4: Domestic and International Trade Costs

A. Domestic Trade Cost Estimates		
	Coefficient	Standard Error
I(Different Cities, Same Province)	0.0001	(0.0572)
I(Different Provinces, Same Region)	1.0897	(0.0719)
I(Different Regions)	1.2276	(0.0507)
I(Sharing Provincial Border)	-0.0648	(0.0393)
I(Same Province)*Distance	-0.0003	(0.1829)
I(Different Provinces, Same Region)*Distance	0.1836	(0.0683)
I(Different Regions)* Distance	0.0833	(0.0206)
Cultural Distance	0	(0.0554)
Observations	900	
R^2	0.70	

B. International Trade Cost Calibration: Targets and Parameter Values		
	Trade/Production	International Trade Costs
Agricultural Industry	0.12	0.93
Manufacturing Industry	0.36	0.75
Capital and Equipment Industry	0.46	0.67

Notes: Panel A of this table reports the estimates of domestic trade costs. Robust standard errors are in parentheses; *Distance* is measured as the great circle distance between cities (in 1000 km); *Cultural Distance* is measured as one minus the correlation in lagged ethnic minority shares between each city pair. Panel B of this table reports the level of industry openness in the data, and the calibrated international trade costs. The data on sectoral-level trade is aggregated from the 2005 UN Comtrade database. Production data is from the 2005 statistics yearbook.

domestic trade cost structure.

Panel B of Table (4) presents the level of sectoral international openness in China, defined as trade over production. Capital and manufacturing industries are more open compared to the agricultural industry, and this is reflected in the higher calibrated sectoral trade costs for the agricultural industry. Consistent with anecdotal evidence, international trade costs are smaller than the estimated inter-provincial costs, capturing the feature in the data that coastal provinces trade much more intensively with the ROW than with interior provinces.[31]

6.5.3 Additional Validations of the Model

The good fit of the migration and trade model suggests that it is a reasonable approximation of the Chinese economy. Since I fully parameterize the model, I can look at additional moments that are not targets of calibration or estimation, to further assess the fit of the model.

Table (5) presents the summary statistics for city-level openness, and the correlation between

[31] In a state council meeting in 2014, Prime Minister Keqiang Li mentioned the complaint of producers in Shanghai that shipping costs within China were so high that it was cheaper to ship goods to California than to Beijing.

Table 5: Non-targeted Moments

	Data	Model
Trade/Labor VA: mean	0.45	0.41
Trade/Labor VA: std	0.86	0.58
Corr (Trade/VA, Wage)		
For Worker Group:		
Urban unskilled	0.29	0.26
Rural unskilled	0.37	0.33
Urban skilled	0.25	0.14
Rural skilled	0.41	0.23

Notes: The data sample excludes the top 1% most open cites, with trade/GDP greater than 3, which is also the highest level of openness predicted by the model. *Trade/Labor VA* refers to the ratio between trade (imports+exports) and total payments to labor.

city openness and average wage.[32] Overall, the model performs reasonably well in this test. It reproduces the mean city openness and the correlation between openness and wages for unskilled workers. It also captures the higher correlations between wages and trade in the rural sector compared to the urban sector for both types of workers. However, the model under-predicts the dispersion of city level openness, and the correlation between openness and wage, for high skilled workers.

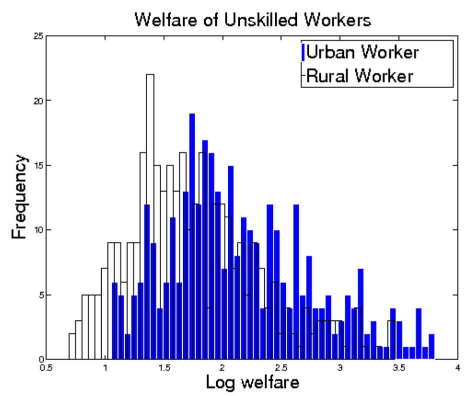
6.5.4 Welfare and Productivity Distribution in the 2005 Equilibrium

I compute the expected value of the welfare of workers, defined by Equation (5), by their places of birth. Figure (3) plots the density distribution of the log welfare for different worker groups. There is considerable dispersion in welfare among all worker groups. Among skilled workers, those born in cities with desirable amenities or high wages can be 150-250 log points better off than those born in other cities; among unskilled workers, the dispersion is even larger. Figure (4) plots the wage for each region (y axis) against the region's calibrated productivity (x axis). In both rural and urban sectors, wages clearly increase with local productivity; through the lens of the trade model, high wages imply high productivity in equilibrium. But because of the differences in market access across regions, the relationship is not perfect; if the trade costs were identical for each trading partners, the competition between producers in different regions would impose a perfect relationship between wages and productivity.

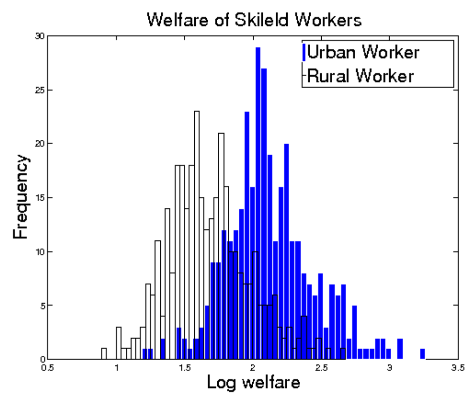
These two sets of figures underscore the importance of limited worker mobility and internal

[32] City openness is computed as the sum of imports and exports, divided by local labor value-added. Since the model does not incorporate all primary inputs to GDP (e.g., land), for consistent comparison, I normalize city-level trade by wage payment instead of GDP.

Figure 3: Welfare Distribution

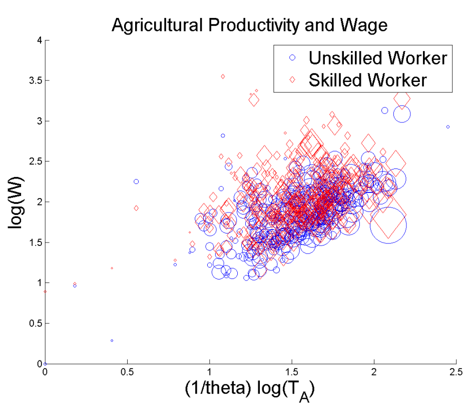


(a) Welfare of Unskilled Workers

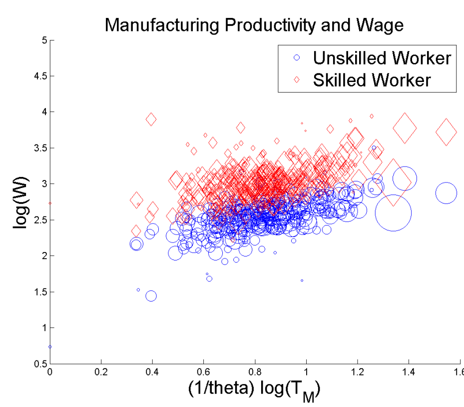


(b) Welfare of Skilled Workers

Figure 4: Wage and Productivity



(a) Rural Wage and Agricultural Productivity



(b) Urban Wage and Manufacturing Productivity geography in determining both trade and welfare. It is therefore critical to take these two elements into account when studying the welfare implications of trade.

7 Counterfactual Experiments

7.1 Benchmark Experiment

I use the model as a laboratory to conduct a sequence of policy experiments in order to examine the impacts of trade on welfare and inequality and the roles of within-country frictions in determining these impacts. In the first experiment, I keep all parameters of the model at the calibrated values and shut down the international trade between China and the ROW by increasing the international trade costs to infinity.

7.1.1 Impacts of Trade on Welfare and Inequality

I compute the welfare gains from trade for each type of worker, by calculating the relative changes in their welfare as China moves from the autarky to the open economy equilibrium.[33] Panel A of Table (6) reports the mean, standard deviation, and 5% and 95% percentiles of the distribution of welfare gains from trade, by workers' skill groups. I compute the national average gains from trade by averaging over all worker groups in all regions, weighted by population. The national average gains from trade are 7.61%, similar in magnitude to the predictions of models without within-country heterogeneity and internal frictions.[34] However, the welfare gains do not accrue to everyone in the economy equally. First, different types of workers benefit differently from trade. The average gains from trade are about 11% for skilled workers, and 5% for unskilled workers. Within the group of workers with a similar level of skill, the impacts of trade also differ dramatically; among all worker groups, the standard deviations of the distributions of the welfare gains are similar to, or larger than, the respective means. The most-benefited group receives a welfare improvement of 20-30%, while some workers, likely unskilled ones, could experience welfare losses.

These patterns suggests that international trade might have important impacts on inequality, between workers with different skills, and among similar workers from different regions. I use the Theil index to measure the overall inequality in real wages in China, decomposing it into between-region and within-region components, and examine the impacts of international trade on each component.

Panel B of Table (6) presents the results. The first row is the decomposition for the benchmark

[33]If we use per-capita real wage as the proxy for income and welfare, both qualitative and quantitative results hold.
[34]See, for example, Parro (2013) and Burstein et al. (2013)

Table 6: Aggregate and Distributional Impacts of Trade

A. Gains from Trade for Different Worker Groups				
	Mean	std	5%	95%
Urban Skilled	11.48	11.29	1.50	30.86
Urban Unskilled	5.19	8.43	-1.86	19.61
Rural Skilled	11.02	10.78	1.74	29.98
Rural Unskilled	4.98	8.31	-1.62	19.71
National Average	7.612			

B. Impacts of Trade on Inter- and Intra-Regional Inequality			
	Between Region	Within Region	Theil Index
Open Economy	0.182	0.031	0.213
Autarky	0.172	0.025	0.197
Increase (%)	5.8%	24.0%	8.15%
Relative Contribution	63.5%	36.5%	100%

Notes: Panel A of this table reports the summary statistics of the city-level welfare gains from trade for different worker skill groups. All numbers are in percentage points. *National Average* is the population-weighted average (across regions and worker skill groups) gains from trade. Panel B reports the decomposition of inequality, measured by the Theil index, into within- and between-region components in both the autarky and the open economy. The last row reports the relative contributions of the two components to the increase in the aggregate inequality after trade liberalization.

economy. The between-region component constitutes about 90% of the overall inequality in China, while the within-region inequality between skilled and unskilled workers contributes only 10%. The second row of the table is the decomposition for the autarky economy. Again, the between-region component contributes more than 80% to the overall inequality.

As reported in the third row of Panel B, moving from the autarky economy to the open economy, the overall inequality in the country increases by 8%; both between- and within-region inequalities increase. Although the within-region component accounts for only about 10% of inequality, its contribution to the increase is 36%. The between-region component accounts for the remaining 64% of the increase in aggregate inequality.

7.1.2 Trade and Inequality: the Role of Internal Geography

The decomposition in the previous section suggests that both within- and between-region components matter in the context of impacts of trade on inequality. Since, in the model, one important difference between regions is their geographic environments, in particular, their accesses to foreign markets, in this section, I examine to what extent geography can explain the impacts of trade on different regions.

Each panel in Figure (5) plots the city-level average welfare gains from trade for one worker group. The vertical axis is the ratio between the average welfare in the open economy and the average welfare in the autarky; the horizontal axis is each city's distance to its nearest port; the size of bubbles indicates city size. In all panels, regions form two groups in terms of their gains from trade: a coastal group that reaps most of the benefits and an interior group that benefits very little. For unskilled workers, some interior regions lie below 1, indicating that residents there bear welfare losses. The segregation of gains from trade is reminiscent of the segregation in terms of international trade integration in panel (a) of Figure (2): cities in the coastal provinces trade much more intensively with the ROW than with most interior cities. By limiting free mobility of goods within the country, intra-national trade costs indeed prevent interior regions from benefiting from trade.[35]

To illustrate the impacts of international trade on within-region inequality and how the impacts differ along the geographic dimension, Figure (6) plots *changes* in skill premia in rural and urban regions against regions' distances to their nearest ports. In the urban sector, except for a couple of regions in the hinterland, almost all regions experience increases in their skill premia after trade. The increase is around 10% in the coastal areas and about 5% in the interior. In the rural sector, on average, skill premia increase by 5% in coastal regions but decrease by 1-2% in the interior. The negative correlation between changes in skill premia and distances to the coast is consistent with empirical findings from a diff-in-diff approach (Han et al., 2012).

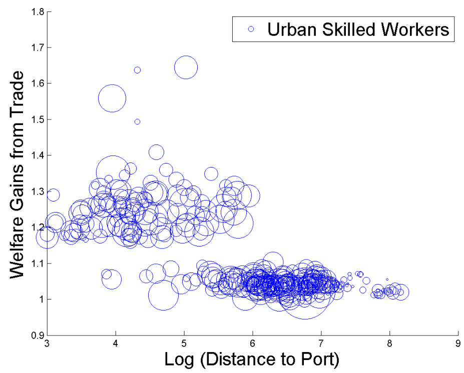
These figures illustrate clearly that within-country geography is relevant for workers' gains from trade. The prediction that, within each skill group, workers from the coastal regions benefit more, is intuitive: international trade is, on average, welfare-improving, and since coastal regions trade more, workers there also benefit more. On the other hand, the forces behind the differential impacts of trade on skilled and unskilled workers within the same region (i.e., the changes in skill premia) and how the differential impacts vary across locations (i.e., the negative gradient of the changes in skill premia with respect to regions' distances to the coast) are less obvious. The next section will explain these patterns.

7.1.3 Explaining the Gradient of Changes in Skill Premia

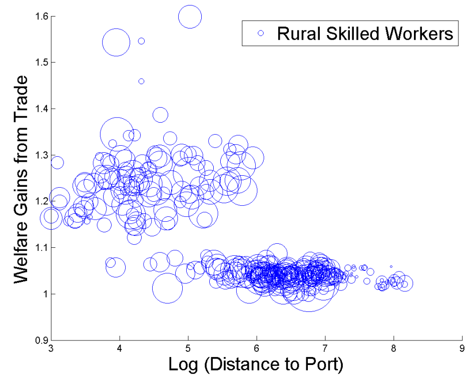
The impacts of international trade on skill premia rest on its impacts on the relative demand and the relative supply of skilled versus unskilled workers. I discuss forces affecting these two

[35] The discontinuities in the gains from trade in Figure (5) as we move along the horizontal axis from the interior to the coast are largely driven by the large estimated value of the inter-provincial dummy in the domestic trade specification. As discussed in Section 5.5, and more in Online Appendix C, I might potentially misattribute the costs of shipping over geographic distance to the provincial dummy. To address this concern I perform a robustness check, reported in the appendix, with a more continuous domestic trade cost structure (while keeping the overall level of domestic trade costs unchanged) and show all results are robust to this alternative domestic trade cost structure.

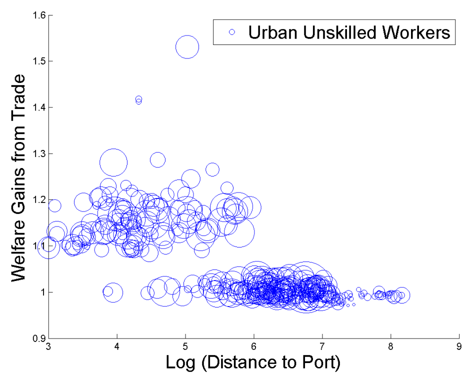
Figure 5: Geographic Distribution of Gains from Trade



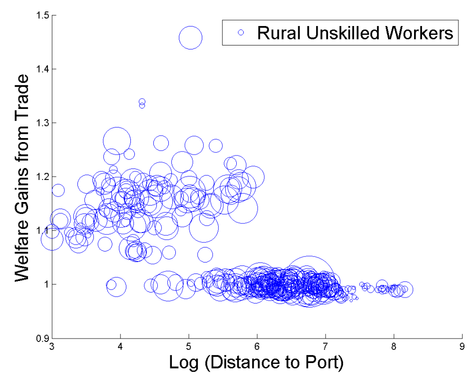
(a) Welfare Effect: Urban Skilled Workers



(b) Welfare Effect: Rural Skilled Workers

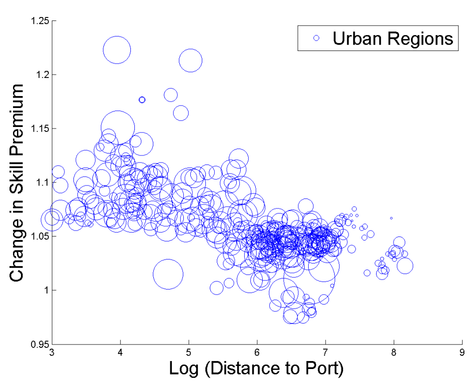


(c) Welfare Effect: Urban Unskilled Workers

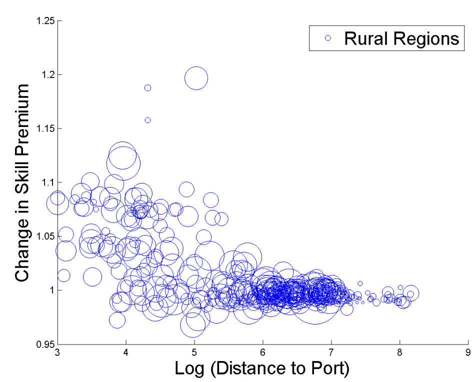


(d) Welfare Effect: Rural Unskilled Workers

Figure 6: Trade and the Skill Premium



(a) Change in Urban Skill Premium



(b) Change in Rural Skill Premium

factors separately.

The factor content theory of trade predicts that in open economy, a developing country with abundant unskilled labor will specialize in producing and exporting unskilled-intensive products. Because of the change in specialization pattern, after trade, the relative demand for unskilled labor increases. The "Stolper-Samuelson Theorem" then predicts a decrease in the skill premium in developing countries following trade liberalization. This channel, however, is *not* an important channel in the current context: trade between China and ROW is largely within sector; therefore the change in relative demand for workers induced by the factor content of trade is unlikely to be large.[36]

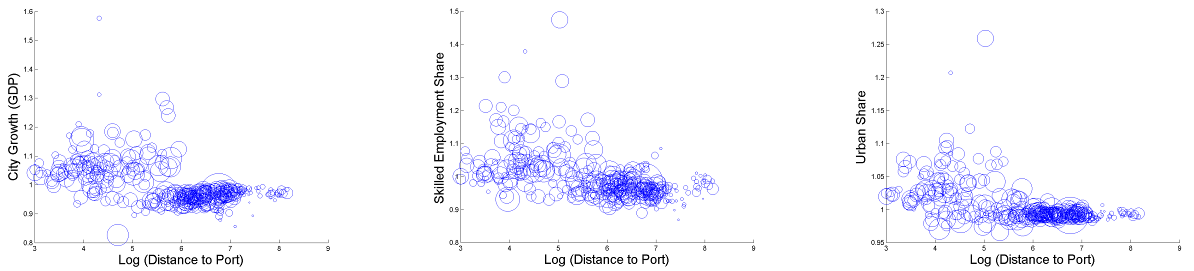
A channel related to the factor content theory of trade, but operating through within country specialization, is important. Because the urban tradable industries (K and M industries) employ intermediate goods more heavily than the agricultural industry, they are more "transportation intensive." When a country opens up to trade, the coastal regions, due to their proximity to foreign suppliers, have stronger comparative advantages in these industries, and specialize in producing capital and manufacturing products. The interior regions, on the other hand, specialize in the agricultural industry. This shift in specialization patterns increases the relative demand for skilled workers in the coastal regions and decrease it in the hinterland, resulting in a negative relationship between the increases in regional skill premia, and regions' distances to ports, as shown in Figure (6).

A second channel that affects relative demand for skilled workers is the capital-skill complementarity in production. China is a net importer of capital goods, which are complements to skilled workers. As a result, after the international trade liberalization, skill premia increase across the board. Because coastal regions experience larger drops in the prices of capital goods, skill premia increase more on the coast.

Now consider changes in skill compositions across regions after trade liberalization. A region's change in skill composition is determined by the *net* numbers of skilled/unskilled labor units migrating into that region, which in turn depend on regions' access to labor pools and workers' costs of migration. Since the coastal regions gain more from trade, they will experience a net gain in population. As the estimated migration costs are lower for skilled workers, there will be more skilled workers moving from the interior into the coastal regions, pushing down skill premia on the coast and driving them up in the interior. The differential mobility between skilled and unskilled

[36] In the model, all industries in the urban sector uses the same composite equipped labor, with the same skill intensity, so the factor content of trade theory can only operate through the reallocation of workers between urban and agricultural sectors; and this force is less important, because surplus is only 1% of production in the agricultural industry. Even if we allow capital and equipment industry to have a different skill intensity from the manufacturing industry, the factor content of trade is unlikely to change much, because the deficit in capital and equipment industry is less than 2% of production.

Figure 7: Reallocation After Trade



(a) City Growth (b) Skill Share in Employment (c) Urban Share in Value Added

workers constitutes a third channel that tends to flatten the gradient of changes in skill premia and offset the channels described above.

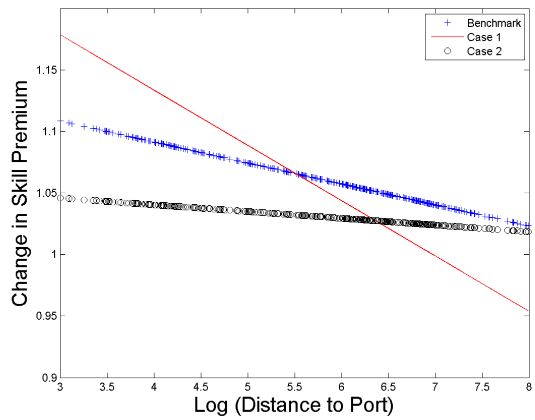
Apart from capital skill complementarity, the two other channels work through reallocation of workers across regions or sectors. I provide evidence of the reallocation pattern predicted by these channels in Figure (7). Panel (a) plots the changes in a city's GDP against its distance to port and shows that coastal cities expand after trade at the expense of interior cities, due to the movements of workers from the interior to the coast. Panel (b) plots each city's skill share in local employment. Consistent with the prediction from the differential mobility channel, skill shares increase in the coast, and decrease in the hinterland. Finally, Panel (c) plots the share of urban value added in each city. As predicted by the "Domestic Stolper-Samuelson Effect", the share of urban value added in local economies increases on the coast and decreases in the hinterland.

To illustrate the quantitative importance of these channels, I conduct a sequence of counterfactual exercises and plot the changes in skill premia in these experiments in Figure (8).[37] "Benchmark" refers to the previous experiment. Experiment "Case 1" increases skilled workers' migration costs to the level of unskilled workers; experiment "Case 2" further shuts down capital skill complementarity by setting both the elasticity between capital and skilled worker and the elasticity between equipped and unskilled worker to 1.1, the estimates of Dix-Carneiro (2014) using a symmetric CES specification. In both cases, I compute the open economy and autarky equilibria and calculate the changes in wages and welfare as the country opens up to trade.

In Figure (8), when migration costs are the same for skilled and unskilled workers, the gradient for the changes in skill premia becomes steeper. The coastal regions now experience around 15% increases in skill premia, 5% points higher than in the benchmark experiment, and the interior regions experience about 5% decreases in skill premia. When I further shut down capital-skill complementarity, while there is still a mild gradient, the fitted line shifts downward, and becomes

[37] For ease of comparison, I plot only the fitted value from a weighted least squares regression of changes in skill premia on regions' distances to port.

Figure 8: Changes in the Skill Premium



Notes: Each line is the fitted value from the weighted (by city size) least squares regression of changes in skill premia on the log of cities' distances to coast. Case 1: equal migration costs for both types of workers. Case 2: equal migration costs *and* no capital-skill complementarity.

flatter, as expected. Globalization now increases within-region inequality more evenly across regions.

These experiments suggest that the various channels related to internal geography are all quantitatively important for both the geographic dimension, and the skill dimension of the distributional impacts of trade. In particular, the "Domestic Stolper-Samuelson Effect" is unexplored previously. Operating through changes in domestic specialization patterns, this channel has important implications for measuring regional trade exposures: since the interior regions in the country trade little with the ROW, most conventional measures of trade exposure will overlook these regions' exposures. However, because of international trade liberalization, the economic environment of these regions change dramatically. It is therefore important to take into account not only regions' international trade participation but also their trade with domestic partners, in measuring the regional impacts of trade.

7.2 Trade Liberalization Under Alternative Internal Geographies

In this section, I perform four additional experiments to examine how the distributional impacts of international trade differ in economies with different internal frictions. The answer to this question bears policy significance, as many countries that have recently experienced trade reforms are also liberalizing their domestic labor markets, or constructing large transportation infrastructure projects aimed at lowering domestic trade costs.

In all four experiments, I solve the model for its open-economy equilibrium, in which international trade costs are set at the calibrated values, and the autarky equilibrium, in which international trade is shut down. Across these experiments the model economy differs in its intra-national frictions, due to hypothetical domestic reforms: in the first experiment, the inter-provincial trade costs are set to the U.S. level; in the second and third experiment, the inter-provincial migration costs for skilled and unskilled workers, respectively, are set to the U.S. level; the fourth experiment combines all these changes. I report the sources and values of the geographic parameters for the U.S. economy used in these experiments in the appendix.

Table 7: Trade and Inequality: Different Domestic Frictions

A. Statistics by Worker Category										
	Benchmark		(2) TC		(3) SMC		(4) UMC		(2)+(3)+(4)	
	Mean	std	Mean	std	Mean	std	Mean	std	Mean	std
Urban Skilled	11.48	11.29	9.01	5.78	12.12	3.87	14.19	10.88	6.60	1.73
Urban Unskilled	5.19	8.43	4.49	3.86	7.18	9.28	3.73	2.60	2.83	1.27
Rural Skilled	11.02	10.78	8.81	5.22	10.81	3.58	13.80	10.65	6.30	1.60
Rural Unskilled	4.98	8.31	3.79	3.39	4.69	8.96	2.87	2.46	2.35	1.10

B: Aggregate Statistics					
	Benchmark	(2) TC	(3) SMC	(4) UMC	(2)+(3)+(4)
National Average	7.61	4.95	6.42	5.35	3.28
Trade Openness	60.13	41.18	58.12	48.82	31.46
Increase in Inequality(%)	8.15	3.50	7.14	5.78	1.52
Contribution-Between (%)	63.54	36.32	87.77	40.27	5.13
Contribution-Within (%)	36.46	63.68	12.23	59.73	94.87

Notes: This table reports the effects of trade on welfare and inequality in economies with different internal geographies. All numbers are in percentage points. The first column, *Benchmark*, is the same as the experiment reported in Table (6); *TC* refers to the case with lower domestic trade costs; *SMC* refers to the case with lower skilled migration costs; *UMC* refers to the case with lower unskilled migration costs; the final column combines the reductions to trade costs, skilled migration costs, and unskilled migration costs. Panel A reports the means and standard deviations of city-level welfare gains from trade for different worker groups. Panel B reports national average welfare gains, changes in inequality after trade, and the compositions of the changes in inequality. The measures for average gains from trade and inequality are the same as in Table (6). *Trade openness* is defined as the sum of imports and exports over GDP.

Table (7) reports the results of these experiments. The first column is the benchmark experiment. The second column is the experiment with lower intra-national trade costs. Panel (A) reports summary statistics for welfare impacts by worker group. Compared with the benchmark experiment, there are two major differences. First, with lower domestic trade costs, the overall gains from trade are smaller for all worker groups. Second, within the group of workers with similar level of skills, the impacts of trade are more evenly distributed: compared to the benchmark case, the standard deviations of the welfare impact decrease by about 50% for all worker groups. Despite the differences, skilled workers still benefit more than unskilled workers, by 5 percentage points on average, a magnitude similar to that in the benchmark case. Therefore, the impacts of trade on within-region, between-group inequality are similar to those in the benchmark case, too. Panel (B) reports the changes in aggregate welfare and inequality. When the internal trade costs are smaller, the economy trades less with the ROW, and the national gains from trade are also smaller, around 5%. The increase in overall inequality is 4%, about half of the benchmark level, and 64% of this increase is due to an increase in the within-region inequality between skilled and unskilled workers. This is consistent with the findings reported in Panel A: the within-group inequality plays a more important role than in the benchmark case.

In the third and fourth columns, I report the results from the experiments in which labor market reforms reduce the inter-provincial migration costs to the U.S. level, for skilled and unskilled workers separately. Intuitively, a decrease in migration costs for workers of one skill level will decrease the impacts of trade on the between-region inequality within that worker group, as measured by the standard deviations of the welfare effects for the worker group. This intuition holds true for both skilled and unskilled workers. Perhaps surprisingly, when we reduce the migration costs for unskilled workers, on average, skilled workers benefit even more than in the benchmark case. This is because the mean average gains from trade for each worker group are largely driven by the gains from trade of the workers from the coastal regions. As more unskilled workers migrate to the coast, skill premia increase by more on the coast than in the benchmark case, and as a result, the within-region component accounts for a higher proportion of the increase in the aggregate inequality.

In the last experiment, I combine all three reforms; so domestic trade costs, and migration costs for skilled and unskilled workers are all lower. The average gains from trade are only 3.3%, less than half of the benchmark value. The standard deviations of the welfare impacts within all worker groups are also much smaller. As a result, the inequality in the economy increases by only 2%. This result suggests that reforms in domestic markets for goods and labor are complementary to each other for a more even distribution of the gains from trade.

Throughout these experiments, as the domestic markets become more liberalized, the country participates less actively in international trade and therefore receives smaller gains from trade. This result stands in contrast to the empirical findings (see, for example, Cosar and Demir, 2014) that better domestic infrastructures increase regional exports. Two reasons explains why the aggregate effects are different from the empirically identified effects: first, with lower domestic frictions, the coastal regions now trade more with the interior and less with the ROW; second, as the interior regions become better connected, they are more attractive as destinations, and more workers stay or migrate there. The size of the coastal regions—the regions that originally trade more intensively with the ROW—shrink, and therefore, the country's aggregate international trade decreases.

7.3 Sensitivity Analysis

This section reports the sensitivity analysis of the results to the parameters that are calibrated outside the model. Since the choice of these parameters affect the equilibrium distribution of wage, for each new parameters, I recalibrate regional productivity to match the 2005 equilibrium, and then solve the corresponding autarky equilibrium for the welfare effects of international trade.[38]

Table 8: Sensitivity Analysis

Parameters	Openness	Average Gain	Inequality Increase	Contribution (%)	
				Between	Within
Benchmark	60.13	7.61	8.15	63.54	36.46
$\rho_{kh} = 0.67, \rho_{lkh} = 1.1$	60.14	7.83	7.48	67.70	32.30
$\rho_{kh} = 1.1, \rho_{lkh} = 1.67$	60.29	7.69	6.56	69.94	30.06
$\rho_{kh} = 1.1, \rho_{lkh} = 1.1$	60.28	8.01	5.12	78.11	21.89
$\rho = 0.2 : R^2 = 0.6$	58.34	7.09	9.52	66.39	33.61
$\rho = 0.55 : R^2 = 0.8$	60.45	7.78	7.17	61.49	38.51
$\theta = 4.5$	46.57	4.89	6.72	64.03	35.97
$\theta = 5$	35.81	3.16	5.43	63.36	36.64

Notes: This table reports the effects of trade on welfare and inequality under alternative parameterizations. All numbers are in percentage points. Measures for average gains from trade and inequality are the same as in Table (6). *Trade openness* is defined as the sum of imports and exports over GDP.

The elasticity of substitution between capital and skilled workers, ρ_{kh}, and the elasticity between equipped skilled workers and unskilled workers, ρ_{lkh}, are important parameters in the model. For robustness, I first reduce ρ_{lkh}, to 1.1, implying that the upper nest is close to the Cobb-Douglas production function. I then increase ρ_{kh} to 1.1, keeping ρ_{lkh} at the benchmark level. Finally, I treat capital, skilled workers and unskilled workers as symmetric input into composite labor production by setting both ρ_{lkh} and ρ_{kh}, to 1.1. Rows (2)–(4) in Table (8) report the findings. As we can see, the aggregate gains from trade remain similar, while the changes in aggregate inequality and the contributions from the within-region component become smaller, as expected.

In the previous analysis, I calibrate the correlation between an individual's productivity draws across regions, ρ, to 0.4, to match the explanatory power of individual fixed effects in panel wage regression: individual fixed effects explain 70% of the remaining variation in wages, after controlling for regional fixed effects and individual demographics. I perform the policy experiment again, for $\rho = 0.2$ and $\rho = 0.55$, corresponding to an explanation power of 60% and 80%. Rows (5) and (6) in Table (8) report the findings. The results do not change much.

[38] This is different from the previously reported experiments in which we change only the exogenous parameters, without calibrating the economy to the 2005 equilibrium again. There, the goal was to understand the impacts of trade, in an otherwise similar economy with different structural parameters, so I kept regional productivity at the calibrated level.

Finally, I increase the elasticity of trade, θ, from 4 to 4.4 and 5, and conduct the same exercise. The last two rows in Table (8) reports the results. When trade is more elastic, the country, in particular the coastal regions, benefits less from trade liberalization. Because of this, fewer people will migrate to the coast, further reducing the country's trade with the ROW. The increases in overall inequality are also smaller in these two cases.

Overall, the experiments suggests that the conclusions of the paper are robust to alternative parameter values.

7.4 Discussion on Modeling Assumptions

In modeling the economy, I make several assumptions. In this section, I discuss how the violations of these assumptions would affect the main results.

In terms of the timing of migration, I assume that workers learn their idiosyncratic productivity draws in all regions prior to their move. Admittedly, in reality, there is substantial uncertainty about the payoffs to migration, which can be inferred from the fact that many migrants return to their birthplaces shortly after their migration (Kennan and Walker, 2011). In the empirical analysis, I classify workers as migrants if they are currently not in their birthplaces. Some of them might be temporary migrants who will shortly return to their hometowns. However, these migrants are unlikely to constitute an important part of the total migrants: even if 50% of migrants are temporary workers who return to their hometowns within two months, over a period of twenty years, the stock of migrants in each place will mostly be the permanent ones. My estimates of the migration costs, then, correspond to the long-run migration costs, which could be interpreted as reduced-form approximations of the real migration costs when there is uncertainty.

I use the Frechet distribution to model individuals' productivity draws. This distribution is a reasonable approximation of the wage distribution. In particular, it has a fat right tail. Most existing work in the migration literature makes similar parametric assumptions, using Logit or Pareto distributions. Instead of treating idiosyncratic migration decisions as outcomes of idiosyncratic individual preference shocks, an approach commonly adopted in migration literature, I assume they are driven by idiosyncratic productivity shocks, as in Ahlfeldt et al. (2012). The advantage of this approach is that, while individual preference is unobservable, parameters governing productivity shocks can be inferred directly from the wage distribution. The Frechet distribution is particularly attractive because under this assumption, we have tractable expressions to aggregate supply of efficiency units in each region. However, all the channels discussed in the paper would apply under other distributional assumptions.

Since China's economy is growing quickly, and my model is static, one might worry that this discrepancy will make my results less useful. In analyzing the potential problems, it is important to be clear what dynamics one has in mind. First of all, the demographic structures are changing over time. My framework is general enough to incorporate multiple age groups, but I abstract from this mainly because of the limited sample size. Hence, my estimates could be interpreted as average migration costs across different age groups. If we want to simulate how the economy would evolve in the long run for a future policy change, it would be problematic because the future demography is different. However, the counterfactual experiments are backward looking; the counterfactuals aim to analyze the implications of China's *past* trade integration on welfare, when there are different magnitudes of internal frictions. Hence, the changing demography will not invalidate the results.

Another potential threat is that in 2005, the domestic labor markets are not yet in equilibrium; that is, there is potential migration that has not been realized. The existence of those workers will result in overestimating regional fixed effects for the regions experiencing migration outflows, and given the observed wages, this will in turn be reflected in overestimated amenities in these regions; similarly, I will under-estimate the amenities in popular migration destinations. In quantification, I find large dispersion in amenities, and if this argument is true, the real dispersion will be larger. In counterfactual experiments, however, since I keep the amenities fixed, the biases in the measured amenities will not affect the relative changes in the variables of interest, between trade and autarky equilibrium.

8 Conclusion

This paper studies the aggregate and distributional impacts of trade on an economy with internal trade costs and migration costs. Focusing on China, I find that relative to the aggregate welfare gains, the distributional impacts of trade are large: the average welfare gains are about 7%, and the increase in overall inequality, as measured by the Theil index, is around 8%. Both the between-region inequality among workers with similar skill levels, and the within-region inequality between workers with different skill levels, contribute significantly to the increase in overall inequality. Reforms in domestic markets factors or goods market increase the internal integration of the country and reduce the effects of international trade on inter-regional inequality, but also reduce the welfare gains from international trade integration.

The impacts of trade on skill premia are not even across regions. Counterfactual experiments show that differential mobility between skilled and unskilled workers and changes in specialization pattern of regions *within* the economy are important for the change in the gradient of skill premia. As neither of these forces arises in a model without frictional domestic trade or migration, it is important to take into account the role of internal geographic, even when the interest is in the impacts of trade on the skill premium.

The framework developed in this paper can be applied to other settings. For example, it can be used to evaluate the welfare implications of the Transatlantic Trade and Investment Partnership. It is plausible that such an important policy change would lead to more migrations from Eastern Europe to Western Europe. The framework here incorporates remittances and multiple worker types, and is particularly suited for such an analysis, as immigrants are likely to be less skilled than native workers, and their remittances are an importance source of revenue for many countries.[39]

This paper abstracts from some interesting and important aspects of the real world that could affect the impacts of international trade liberalization. For example, regional agglomeration effects might amplify both the distributional and the aggregate impacts. Both agglomeration and dynamic effects are potentially important features to incorporate into future research.

References

Ahlfeldt, Gabriel M, Stephen J Redding, Daniel M Sturm, and Nikolaus Wolf, "The Economics of Density: Evidence from the Berlin Wall," *CEP Discussion Paper 1154*, 2012.

Akay, Alpaslan, Corrado Giulietti, Juan D Robalino, and Klaus F Zimmermann, "Remittances and Well-being among Rural-to-urban Migrants in China," *Review of Economics of the Household*, 2012, pp. 1–30.

Allen, Treb and Costas Arkolakis, "Trade and the Topography of the Spatial Economy," *The Quarterly Journal of Economics*, 2014, *129* (3), 1085–1140.

Alvarez, Fernando and Robert E Lucas, "General Equilibrium Analysis of the Eaton–Kortum Model of International Trade," *Journal of Monetary Economics*, 2007, *54* (6), 1726–1768.

Arkolakis, Costas, Arnaud Costinot, and Andres Rodriguez-Clare, "New Trade Models, Same Old Gains?," *The American Economic Review*, 2012, *102* (1), 94–130.

Atkin, David and Dave Donaldson, "Who's Getting Globalized? The Size and Nature of Intranational Trade Costs," *Mimeo*, 2012.

Au, Chun-Chung and J Vernon Henderson, "How Migration Restrictions Limit Agglomeration and Productivity in China," *Journal of Development Economics*, 2006, *80* (2), 350–388.

Autor, David H., David Dorn, and Gordon H. Hanson, "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 2013, *103* (6), 2121–68.

[39]For example, in 2012, the remittances received by Armenia accounted for about 11% of its GDP (OECD, 2012)

Bai, Chong-En, Yingjuan Du, Zhigang Tao, and Sarah Y Tong, "Local Protectionism and Regional Specialization: Evidence from China's Industries," *Journal of International Economics*, 2004, *63* (2), 397–417.

Burstein, Ariel, Javier Cravino, and Jonathan Vogel, "Importing Skill-Biased Technology," *American Economic Journal: Macroeconomics*, 2013, *5* (2), 32–71.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, Forthcoming.

_ , _ , Esteban Rossi-Hansberg, and Pierre-Daniel Sarte, "The Impact of Regional and Sectoral Productivity Changes on the US Economy," *NBER Working Paper 20168*, 2014.

Cosar, A Kerem and Banu Demir, "Domestic Road Infrastructure and International Trade: Evidence from Turkey," *Mimeo*, 2014.

_ and Pablo D Fajgelbaum, "Internal Geography, International Trade, and Regional Specialization," *American Economic Journal: Microeconomics*, Forthcoming.

Cosar, Kerem, "Adjusting to trade liberalization: Reallocation and labor market policies," *University of Chicago, Unpublished Manuscript*, 2013.

Costinot, Arnaud and Andrs Rodrłguez-Clare, "Trade Theory with Numbers: Quantifying the Consequences of Globalization," *NBER Working Paper 18896*, March 2013.

Crafts, Nicholas and Alexander Klein, "Geography and Intra-national Home Bias: U.S. Domestic Trade in 1949 and 2007," *Journal of Economic Geography*, 2014.

Dekle, Robert, Jonathan Eaton, and Samuel Kortum, "Global Rebalancing with Gravity: Measuring the Burden of Adjustment," *IMF Staff Papers*, 2008, *55* (3), 511–540.

di Giovanni, Julian, Andrei A Levchenko, and Jing Zhang, "The Global Welfare Impact of China: Trade Integration and Technological Change," *American Economic Journal: Macroeconomics*, 2013.

Dix-Carneiro, Rafael, "Trade Liberalization and Labor Market Dynamics," *Econometrica*, 2014, *82* (3), 825–885.

_ and Brian Kovak, "Trade Reform and Regional Dynamics: Evidence from 25 Years of Brazilian Matched Employer-Employee Data," *Mimeo*, 2014.

Donaldson, Dave, "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure," *The American Economic Review*, Forthcoming.

Eaton, Jonathan and Samuel Kortum, "Technology, Geography, and Trade," *Econometrica*, 2002, *70* (5), 1741–1779.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu, "Competition, Markups, and the Gains from International Trade," *NBER Working Paper 18041*, 2012.

Goldberg, Pinelopi Koujianou and Nina Pavcnik, "Distributional Effects of Globalization in Developing Countries," *Journal of Economic Literature*, 2007, *45* (1), 39–82.

Han, Jun, Runjuan Liu, and Junsen Zhang, "Globalization and Wge Inequality: Evidence from Urban China," *Journal of International Economics*, 2012, *87* (2), 288–297.

Hanson, Gordon, "Market potential, increasing returns and geographic concentration," *Journal of international economics*, 2005, *67* (1), 1–24.

Hanson, Gordon H, "US–Mexico Integration and Regional Economies: Evidence from Border-city Pairs," *Journal of Urban Economics*, 2001, *50* (2), 259–287.

Helpman, Elhanan, Oleg Itskhoki, Marc-Andreas Muendler, and Stephen J. Redding, "Trade and Inequality: From Theory to Estimation," *NBER Working Paper 17991*, 2012.

Hsieh, Chang-Tai and Ralph Ossa, "A Global View of Productivity Growth in China," *NBER Working Paper 16778*, 2011.

_ , Erik Hurst, Charles I. Jones, and Peter J. Klenow, "The Allocation of Talent and U.S. Economic Growth," *NBER Working Paper 18693*, 2013.

Kanbur, Ravi and Anthony J Venables, *Spatial Inequality and Development*, Oxford University Press, 2005.

_ and Xiaobo Zhang, "Fifty Years of Regional Inequality in China: a Journey Through Central Planning, Reform, and Openness," *Review of development Economics*, 2005, *9* (1), 87–106.

Kennan, John and James R Walker, "The Effect of Expected Income on Individual Migration Decisions," *Econometrica*, 2011, *79* (1), 211–251.

Kovak, Brian K, "Regional Effects of Trade Reform: What is the Correct Measure of Liberalization?," *The American Economic Review*, 2013, *103* (5), 1960–1976.

Krugman, Paul and Raul Livas Elizondo, "Trade Policy and the Third World Metropolis," *Journal of development economics*, 1996, *49* (1), 137–150.

Krusell, Per, Lee E Ohanian, José-Víctor Ríos-Rull, and Giovanni L Violante, "Capital-skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, 2000, *68* (5), 1029–1053.

Levchenko, Andrei A and Jing Zhang, "The Global Labor Market Impact of Emerging Giants: a Quantitative Assessment," *IMF Economic Review*, 2013, *61* (3), 479–519.

Limao, Nuno and Anthony J Venables, "Infrastructure, Geographical Disadvantage, Transport Costs, and Trade," *The World Bank Economic Review*, 2001, *15* (3), 451–479.

Ma, Lin, "Globalization and Top Income Shares," *Mimeo*, 2013.

Monte, Ferdinando, "Local Transmission of Trade Shocks," *Mimeo*, 2014.

OECD, "International migrant remittances and their role in development," *International Migration Outlook: SOPEMI*, 2012.

Parro, Fernando, "Capital-skill Complementarity and the Skill Premium in a Quantitative Model of Trade," *American Economic Journal: Macroeconomics*, 2013, *5* (2), 72–117.

Poncet, Sandra, "Measuring Chinese Domestic and International Integration," *China Economic Review*, 2003, *14* (1), 1–21.

_ , "A Fragmented China: Measure and Determinants of Chinese Domestic Market Disintegration," *Review of international Economics*, 2005, *13* (3), 409–430.

Ramondo, Natalia, Andrés Rodríguez-Clare, and Milagro Saborío-Rodríguez, "Trade, Domestic Frictions, and Scale Effects," *Mimeo*, 2014.

Redding, Stephen J., "Goods Trade, Factor Mobility and Welfare," *NBER Working Paper 18008*, 2012.

Simonovska, Ina and Michael E. Waugh, "The Elasticity of Trade: Estimates and Evidence," *NBER Working Paper 16796*, 2011.

Sotelo, Sebastian, "Trade Frictions and Agricultural Productivity: Theory and Evidence from Peru," *Mimeo*, 2014.

Swiecki, Tomasz, "Intersectoral Distortions, Structural Change and the Welfare Gains from Trade," *Mimeo*, 2014.

Tang, Lixin, "Top Income Inequality, Aggregate Saving and the Gains from Trade," *Mimeo*, 2014.

Tombe, Trevor and Jennifer Winter, “Whats Inside Counts: Migration, Taxes, and the Internal Gains from Trade,” *Mimeo*, 2014.

_ and Xiaodong Zhu, “Trade, Migration and Regional Income Differences: Evidence from China,” *Mimeo*, 2015.

Topalova, Petia, “Factor Immobility and Regional Impacts of Trade Liberalization: Evidence on Poverty from India,” *American Economic Journal: Applied Economics*, 2010, pp. 1–41.

Venables, Anthony J and Nuno Limao, “Geographical Disadvantage: A Heckscher–Ohlin–von Thünen Model of International Specialisation,” *Journal of International Economics*, 2002, *58* (2), 239–263.

Wei, Shang-Jin and Yi Wu, “Globalization and Inequality: Evidence from Within China,” *NBER Working Paper 8611*, 2001.

Wolf, Holger C, “Intranational Home Bias in Trade,” *Review of economics and statistics*, 2000, *82* (4), 555–563.

Yang, Dean, “International Migration, Remittances and Household Investment: Evidence from Philippine Migrants Exchange Rate Shocks,” *The Economic Journal*, 2008, *118* (528), 591–630.

Young, Alwyn, “The Razor’s Edge: Distortions and Incremental Reform in the People’s Republic of China,” *The Quarterly Journal of Economics*, 2000, *115* (4), 1091–1135.

Zhao, Yaohui, “Labor Migration and Earnings Differences: The Case of Rural China,” *Economic Development and Cultural Change*, 1999, *47* (4), 767–782.