Trade Liberalization and the Great Labor Reallocation*

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Abstract

What is the role of migration frictions in shaping the effects of trade policy? I address this question by analyzing the impact of tariff reductions on the spatial allocation of labor in China and how this impact depends on migration frictions that stem from China's household registration system (hukou). I first provide reduced-form evidence that trade liberalization has induced significant spatial labor reallocation in China, with a stronger effect in regions with less hukou frictions. I show that the standard quantitative spatial models, by design, would imply that the gains from trade are largely irrelevant to factor market reforms. A more realistic calibration suggests that trade liberalization increases China's welfare by 0.72%, a sizable share of which comes from mitigating the cost of domestic frictions: if China first abolishes the hukou system, the gains from tariff reductions *decrease* by 18%, and its negative distributional consequences are greatly *amplified*. In contrast, a standard spatial model suggests that hukou abolition *increases* the gains from tariff reductions by 2% and *alleviates* its negative distributional consequences.

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1 Introduction

Trade liberalization is often argued to be an important driver of economic development because it can increase a country's income by increasing specialization, providing access to cheap foreign inputs, and facilitating new technology adoption. Prominent trade theories typically focus on long-term equilibrium, assuming that the reallocation of resources across economic activities is frictionless. However, in reality, factor adjustments tend to be slow, costly, and heterogeneous across space. In particular, there is increasing evidence that labor immobility can explain a considerable share of the negative consequences of trade on labor market outcomes.[1] Although the role of labor mobility in shaping the impacts of trade has long been emphasized, we lack a rigorous understanding of how globalization affects a country's internal labor adjustments and how migration frictions shape the general equilibrium impact of tariff reductions.

In this paper, I exploit China's liberalization episode after its accession to the WTO and the country's unique household registration system (hukou) to make three contributions to our understanding of the interaction between trade and migration frictions. First, I provide empirical evidence of the trade-induced spatial labor reallocation and the presence of migration frictions caused by the hukou system. Second, I show that the standard quantitative spatial model by design implies that the gains from trade are largely independent of factor market distortions. That is, the surprisingly weak complementarity found between goods and factor market liberalization found in the quantitative literature is a consequence of specific model assumptions, rather than an informative result from the data. Finally, I quantify the impact of tariff reductions and their interaction with hukou reforms using a more realistic calibration, in which the opposite results emerge from those of the standard model.

China offers a particularly suitable setting to study this subject for three reasons. First, the composition of industries differs significantly across Chinese prefectures, providing ample variation to identify the causal effects of trade policies on regional economic outcomes. Second, although trade has been growing rapidly in China, the country's accession to the WTO was an inflection point: China's total trade in goods was approximately one-half trillion USD in 2000, and it had surged to more than 4 trillion USD by the end of 2010. In the same period, China's internal migration also accelerated. From 1995 to 2000, approximately thirty million Chinese changed their residential province. This number increased to nearly fifty million between 2000 and 2005 and further reached sixty million by 2010.[2] This rapid increase in internal migration is largely a consequence of workers moving from inland areas to coastal cities and contributed the most to China's trade surge over the same period, making the country a natural choice to probe the relationship between international

[1] See, for instance, Autor et al. (2013), Topalova (2010), and Dix-Carneiro and Kovak (2017) for the cases of the US, India, and Brazil, respectively.

[2] The numbers are calculated based on the 2000 and 2010 rounds of the population census and the 2005 round of the 1% population sampling survey.

trade and domestic migration patterns.

Importantly, unlike most policies that tend to affect the movement of *both* goods and people, China's hukou system offers a unique possibility to cleanly identify migration frictions separate from other types of domestic frictions. Introduced in the 1950s, the system has long been recognized as the most important factor restricting internal mobility in China. It ties a person's access to various social benefits and public services to his or her residential status; as a result, the ease of obtaining a hukou substantially influences one's migration decisions. Notably, the stringency of the hukou system differs across provinces. This spatial heterogeneity provides an ideal setting for identifying the role of migration frictions in shaping the impact of trade on regional labor market outcomes.

Drawing on a rich dataset I assembled on China's regional economy, I first empirically document the trade-induced labor reallocation across Chinese prefectures and the presence of hukou frictions. To this end, I develop a novel measure of migration frictions associated with the hukou system based on the hukou-granting probability of each region. Exploiting regional variations in the exposure to tariff changes, I find that among various trade shocks associated with China's accession to the WTO, input tariff liberalization played a dominant role in shaping the spatial labor reallocation.[3] In provinces with the least hukou frictions, the effect of input tariff cuts was three times larger than the average effect. When accounting for both the input and output channels, 29% of the regional variation in employment changes can be attributed to trade liberalization. Regional adjustments on other margins suggest that the observed regional employment changes were mainly driven by inter-regional labor adjustments and confirm the existence of hukou frictions. The estimation results are robust to accounting for various concurrent economic shocks and policy changes including hukou reforms and to instrumenting trade shocks, and I do not find a pre-trend. I also perform a battery of robustness checks and placebo tests to the hukou measure, showing that my results are not driven by the composition of migration inflows, demand factors, or unobserved heterogeneity. The baseline results are also robust when I consider various alternative hukou measures.

Next, I interpret the empirical results through the lens of a quantitative spatial model. For this purpose, I extend the theoretical framework of Redding (2016) to explicitly model input-output linkages and hukou frictions. Importantly, I relax the Cobb-Douglas assumption to allow for more realistic substitution between and across primary factors and intermediate inputs in production and consumption across industries. While the framework can be enriched in various ways, I show quantitatively that deviating from a unitary elasticity of substitution can be important quantify how gains from trade depend on factor market distortions. The key is to recognize under Cobb-Douglas preference and production technologies, all associated share parameters are exogenous. Then, starting from two different initial equilibriums, the extent to which the impact of the same trade shock will differ essentially depends only on the values of a few parameters. In this case, the model is highly likely to predict that trade shocks lead to similar regional income changes regardless

[3]Throughout the empirical analysis, I control for output tariff cuts, external tariff changes and their interactions with the hukou friction measure (among others) and do not find robust evidence of their impacts on migration.

the presence or absence of the hukou system.

Acknowledging this insight, I am able to explain two puzzles associated with the standard spatial quantitative models. Firstly, these models are usually surprisingly sticky, predicting nearly zero interaction effect between trade and various types of factor market frictions.[4] Moreover, when regions positively affected by trade shocks are regions with more hukou restrictions, the model is likely to predict that the removal of hukou restrictions will increase the gains from trade. If trade shocks and hukou frictions are negatively correlated, the model will predict the opposite. Secondly, how domestic friction shapes the distributional effect of trade is most likely to be governed by a reallocation term, which always implies a dampened regional variation in gains from trade when labor become more mobile. These properties disappear once we deviate from Cobb-Douglas, resulting in rich interaction effects shaped by the microeconomic details.

I proceed by calibrating the model to identify the general equilibrium effects of tariff reductions and quantify the importance of hukou frictions. I do so with 30 Chinese provinces and a constructed rest of the world. The simulated regional employment changes match qualitatively well with the observed data. I find that trade liberalization increases China's welfare by 0.72%. However, the welfare gains are not shared equally across provinces. Individuals with a Beijing or a Shanghai hukou experience welfare improvements of 1.85% and 1.58%, respectively, while individuals who hold a hukou from Gansu or Shanxi gain only 0.38% and 0.41%, respectively. Overall, trade liberalization amplifies regional inequalities in China.

I further assess the extent to which China would have gained from trade liberalization if the hukou system had been abolished. To this end, I first quantify the cost of the hukou system. I find that in a province with median hukou frictions, migrant workers are willing to forgo 19% of their income to obtain a local hukou. Abolishing the hukou system improves aggregate welfare by 1.70% and alleviates regional disparities in China, although in regions such as Beijing and Shanghai, hukou holders experience welfare losses. Starting from this new equilibrium, the aggregate gains from the same tariff reductions would decrease by 18% relative to the case with hukou frictions. The gains from tariff reductions also become more unevenly spatially distributed without hukou frictions. In sharp contrast, the standard spatial model with Cobb-Douglas production suggests that hukou abolition increases gains from tariff reductions by 2% and alleviates its negative distributional outcomes.

This paper contributes to a rich empirical literature on trade and local labor markets. Autor et al. (2016) provide a thorough survey of the literature. Unlike most of the work focusing on the downsides of increased import competition (Autor et al. (2013), Dauth et al. (2014), Dix-Carneiro and Kovak (2017), Kovak (2011, 2013), McLaren and Hakobyan (2010) and Topalova (2007, 2010), Facchini et al. (2017), among others),[5] I highlight the positive impact of input trade liberalization

[4]For example between domestic geography and trade in Fan (2019), between commuting costs and trade liberalization in Monte et al. (2015), amongst others.

[5]An exception is Dauth et al. (2014), who found that the rise of China and Eastern Europe caused substantial job

and emphasize the importance of migration frictions in shaping the impact of trade policy. Relatedly, Goldberg and Pavcnik (2007b) and Topalova (2007) find that the poor are more likely to share in the gains from trade liberalization in regions with flexible labor markets. In terms of focus, my paper also broadly connects to the large body of literature on trade and labor allocation in less-developed countries (see Goldberg and Pavcnik (2007a) and Harrison et al. (2011) for surveys) and on trade and costly labor adjustments. Examples include Kambourov (2009), Artuç et al. (2010), Artuç and McLaren (2012), Caliendo et al. (2015), Dix-Carneiro (2014), and many others (see McLaren (2017) for a recent review).

This paper also contributes to a growing body of literature that develops spatial general equilibrium models to analyze the welfare consequences of aggregate shocks while accounting for trade and mobility frictions within countries (for example, Caliendo et al. (2015), Galle et al. (2017), Monte et al. (2015), Redding (2016) and Bryan and Morten (2017)).[6] In the Chinese context, Tombe and Zhu (2019) studies the effect of trade and migration reductions on aggregate productivity, Hao et al. (2020) quantifies the contribution of international migration to structural change, and Fan (2019) investigates how domestic geography and trade affect skill premiums. I add to this literature in three major ways. Firstly, by studying a real-world trade liberalization instead of a counterfactual shock, I am able to guide my model construction with credibly identified empirical evidence and confirm its validity by comparing the observed regional responses with those generated by the model.[7] Secondly, to the best of my knowledge, the hukou friction measure proposed in the paper is the first measure constructed using individuals' actual probability of obtaining hukou, and the only one with sufficient variation and covers all Chinese regions prior to 2000.[8] Finally, I contribute to the literature by showing that it is important to deviate from Cobb-Douglas to quantify the interaction between trade policy and geography.

The remainder of the paper is organized as follows. In the following section, I describe the empirical context, the data, and the variables developed for empirical analysis. Section 3 presents the empirical results. Section 4 describes the theoretical framework. In Section 5, I estimate and calibrate the key parameters of the model, quantify the effects of tariff reductions, and explore a counterfactual scenario in which the hukou system is abolished. Section 6 concludes the paper.

losses in regions in Germany that specialized in import-competing industries but job gains in regions that specialize in export-oriented industries.

[6] Other works studying the interaction between trade and domestic geography include Coşar and Fajgelbaum (2013) and Fajgelbaum and Redding (2014), who have shown that the difference in domestic trade costs to international players can lead to heterogeneous regional development after external integration; Monte et al. (2015) emphasized the role of commuting ties to estimate local employment elasticities; and Ramondo et al. (2016) found that domestic trade costs were substantial impediments to scale effects.

[7] In this sense, my paper is closely related to Caliendo et al. (2021), who quantified the effect of trade and labor market integration due to European Union (EU) enlargement by exploiting observed changes in tariffs and migration policies.

[8] All existing measures are based on hukou legislation, and they have very little variations prior to 2000 since there were few legislative changes.

2 Input Liberalization and Regional Hukou Frictions

In this section, I briefly explain the trade reform and the hukou system in China and describe the data and variables used for the empirical analysis. A more detailed discussion of the data construction and other variables used in this paper, as well as China's trade and hukou reforms, can be found in Appendices A and B, respectively.

2.1 Empirical Context

China's Trade Liberalization

Prior to the economic reforms of the early 1980s, the average tariff level in China was 56%.[9] This tariff schedule was introduced in 1950 and went nearly unchanged in subsequent decades, partly due to the relative unimportance of the trade policy in a centrally planned economy. In 1982, China began to engage in a series of voluntary tariff cuts, driving down the simple average tariffs to 24% in 1996 (Li, 2013). However, the government also introduced pervasive and complex trade controls in the same period – import quotas, licenses, designated trading practices and other non-tariff barriers were widely used (Blancher and Rumbaugh, 2004). In addition, the Chinese RMB depreciated by more than 60% in the 1980s and by a further 44% in 1994, helping firms export (Li, 2013). As a result, changes in tariff duties reflect neither the changes in the actual protection faced by Chinese firms nor the accessibility of imported inputs.

In 1996, to meet the preconditions for WTO accession, the Chinese government engaged in substantial reforms that eliminated most of the restrictive non-tariff barriers. Trade licenses, special import arrangements, and discriminatory policies against foreign goods were reduced or eliminated to make tariffs the primary instruments of protection. Phased tariff reductions started in 2001. In 2000, China's simple average applied tariff was 17%, with a standard deviation across the six-digit Harmonized System (HS6) products of 12%. By the end of 2005, the average tariff level was reduced to 6%, and the standard deviation almost halved. The average tariff level stabilized after 2005.[10] Thus, I measure trade liberalization based on the change in tariff rates between 2000 and 2005.

The Hukou System

A hukou is a household registration record that officially identifies a person as a resident of a region of China and determines where citizens are officially allowed to live. The hukou system was introduced in the early 1950s and was initially used to unify the old household registration system across regions. However, under the planned economy, the system quickly came to be used to restrict the movement of people. At the beginning of the 1960s, migrant workers needed six passes to work

[9] This is the 1982 unweighted average tariff documented by Blancher and Rumbaugh (2004).

[10] All numbers are calculated using the simple average of Most-Favored-Nation (MFN) applied tariffs at the HS6 level from the United Nations' (UN) Trade Analysis Information System (TRAINS).

outside their province, and free migration became extremely rare (Cheng, 2007).

In the early 1980s, China adopted a labor-intensive, export-oriented development strategy that created an increasing demand for labor in coastal cities. As a result, migration policies began to relax over time. Nevertheless, the hukou system continues to serve as the primary instrument for managing inter-regional migration. Due to the continuous influx of cheap labor into the labor market in the 1990s, local governments generally have little incentive to provide public services to migrant workers in the absence of relevant fiscal transfers. Individuals without local hukou do not have access to certain jobs, schooling, subsidized housing, health care, and other benefits enjoyed by those with hukou. As a result, the ease of obtaining a local hukou continues to influence people's decision to migrate.

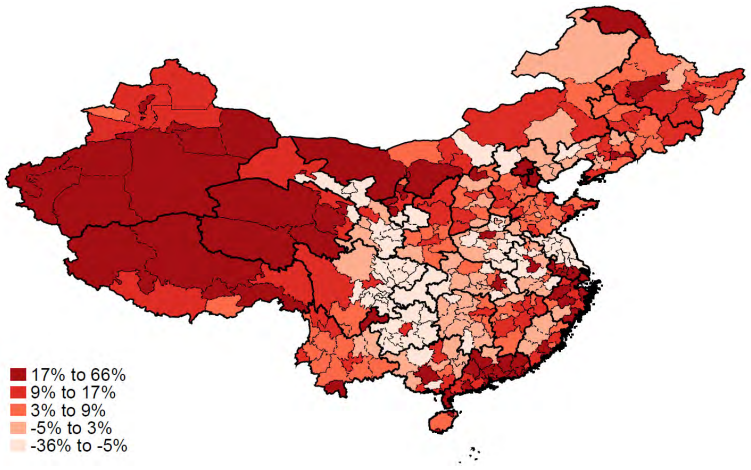
Importantly, as part of a contemporaneous reform devolving fiscal and administrative powers to lower-level governments, local governments have largely gained the authority to determine the number of hukou to issue in their jurisdictions. In 1992, some provinces began to offer temporary resident permits for anyone who had a legitimate job or business in one of their major cities, and some granted hukou to highly skilled professionals (Kinnan et al., 2018). The stringency of these policies and general hukou issuing rules, however, differ significantly across regions. For instance, it is famously difficult to obtain a hukou in Beijing or Shanghai, while Henan is relatively generous in granting local hukou to migrants. This heterogeneity provides a spatial variation that I exploit with the hukou friction measure.

2.2 Data and Measurements

To evaluate the impact of tariff reductions on regional economies in China, I construct a panel dataset of 337 Chinese prefecture-level divisions (prefectures for short). The core data track prefectures decennially from 2000-2010, with the 1990 value being available for some variables. Table A2 contains descriptive statistics of the variables that are used in the paper.

Local Labor Markets

Throughout the empirical analysis, local labor markets are defined as prefectures. A prefecture is an administrative division of China that ranks below a province and above a county. As the majority of regional policies, including the public transportation planning, are conducted at the prefecture level (Xue and Zhang, 2001), I expect counties within the same prefecture to have strong commuting ties and be economically integrated, and thus Chinese prefectures to serve as a good proxy for commuting zones. To account for prefecture boundary changes, I use information on the administrative division changes published by the Ministry of Civil Affairs of China to create time-consistent county groups based on prefecture boundaries in the year 2000. This results in 337 geographic units that I refer to as prefectures or regions, including four directly controlled municipalities and 333 prefecture-level divisions that cover all of mainland China. Compared to the



Notes: Ten-year change in logged prefecture employment. See the text for details.

Figure 1: Regional Employment Changes

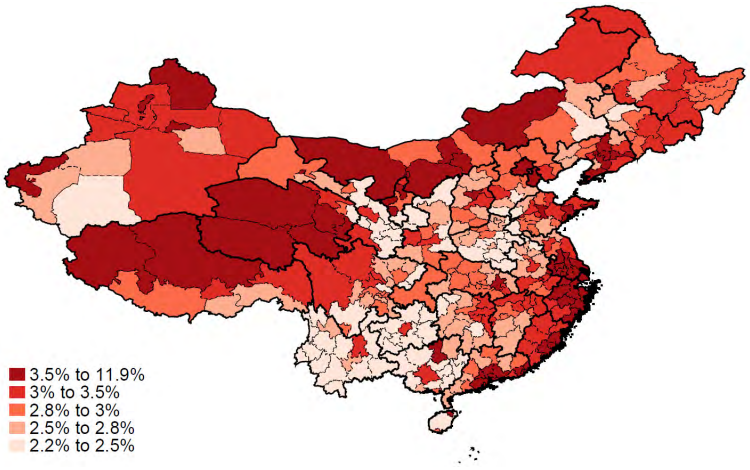
commuting zones in the US, the Chinese prefectures are approximately twice the size on average and 1.5 times the size when the 10 largest (but sparsely populated) prefectures in the autonomous regions are excluded.

The empirical analysis in this paper studies 10-year changes in prefecture employment, total and working age populations, the most recent five-year migrant inflows from other provinces, and the population holding local hukou in each prefecture. I collect these variables at the county level from the Tabulation of Population Census of China by County for the years 2000 and 2010 and then aggregate them to prefectures based on the time-consistent county groups. Notably, the employment measure includes informal workers, the vast majority of which are migrants.[11] Figure 1 shows the prefecture-level employment changes in China between 2000 and 2010. I outline the provinces in bold and the prefectures in dashed lines. The darker prefectures experienced larger employment increases (or smaller decreases). Between 2000 and 2010, China underwent a significant change in its spatial distribution of employment, with some prefectures seeing a more-than 50% increase in local employment, while others faced a more-than 30% decrease.

Regional Trade Shock Exposures

To construct the regional exposure to *input tariff reductions*, I combine data on employment, tariffs, and cost shares. Regional employment by industry is obtained from the tabulation of the 2000 Population Census. I calculate tariff changes using simple averages of the HS6 product-level

[11] According to Park et al. (2012), informal employment in China is defined based on either (i) whether the employer fails to provide all three of the most important types of social insurance that they are expected to provide in China (i.e., pensions, health insurance, and unemployment insurance) or (ii) whether workers have a labor contract. Migrant workers account for 49.0% of informal employment in China under the first definition and 65.7% under the second. The employment data from the population census include all informal workers, provided they engaged in at least one hour of paid work the week before the survey date or were on leave.



Notes: Prefecture exposure to input tariff reductions (2000-2005), with darker prefectures experiencing larger input tariff reductions.

Figure 2: Regional Input Tariff Cuts

MFN tariffs from the TRAINS database. The cost shares for each industry are obtained from the 2002 Chinese national input-output (IO) tables. To utilize these datasets, I construct a common industry classification with 71 industries, including 5 agricultural and 28 nontraded industries.[12] The crosswalk between these datasets is presented in Appendix A, Table A1.

Following Kovak (2013) and Dix-Carneiro and Kovak (2017), I calculate the regional input tariff cuts (ΔRIT) as follows:

$$\Delta RIT_i = \sum_{s \in K} \delta_{is} \Delta IT_s,$$

where $\Delta IT_s = \sum_k \alpha_s(k) \Delta ln(1 + t_k)$ measures the input tariff reductions faced by sector s. The variable $\alpha_s(k)$ represents the cost share of input sector k in s, t_k is the tariff rate of sector k, and $\Delta ln(1 + t_k)$ represents the change in the log tariffs between 2000 and 2005. The weight $\delta_{is} = \frac{L_{is} \frac{1}{\phi_s}}{\sum_{s \in K} L_{is} \frac{1}{\phi_s}}$, where L_{is} is the initial amount of labor allocated to industry s in region i, and ϕ_s is one minus the wage bill share of the industry value added.[13] The weight δ_{is} captures the intuition behind the construction of ΔRIT: a prefecture will experience a larger employment increase if its workers are specialized in industries with large input tariff decreases and more so if these industries are elastic in their labor demand. Nevertheless, my empirical results are robust to simply using initial employment as the weight.

Disparities in the initial industry mix generated substantial regional variations in exposure to input liberalization, as illustrated in Figure 2. The three trade hubs of China, the Bohai Economic

[12]The common industry classification is created to achieve the maximum disaggregation between classifications; the 2002 IO table consists of 122 industries and is coded similarly to the 1994/2002 Chinese Standard Industrial Classification (CSIC1994/CSIC2002). See Appendix A for further details.

[13]In a specific-factor model with a constant-returns production function, $\frac{1}{\phi_s}$ represents the labor demand elasticity (Kovak, 2013).

Rim, the Yangtze River Delta, and the Pearl River Delta, are among the greatest beneficiaries of the input liberalization. Some of the western prefectures also experienced large decreases in regional input tariffs because of these regions specialize in animal husbandry or basic food-processing industries. Those industries are heavy users of agricultural products, the tariffs on which decreased significantly after China's accession to the WTO.

Similar to calculating the regional *input tariff cuts*, I compute regional *output tariff reductions* as a δ_{is}-weighted average of industry-specific tariff reductions. To construct the external tariff changes, I first use the Chinese customs data for 2000 to compute prefecture exports and calculate the export share by destination country for each industry and prefecture. I then take the export-share-weighted average of the tariff changes across destination countries over the 2000-2010 period to obtain prefecture-industry-specific tariff reductions. In the last step, I compute the weighted-average tariff changes across industries using δ_{is} for each prefecture.

The Hukou Friction Measure

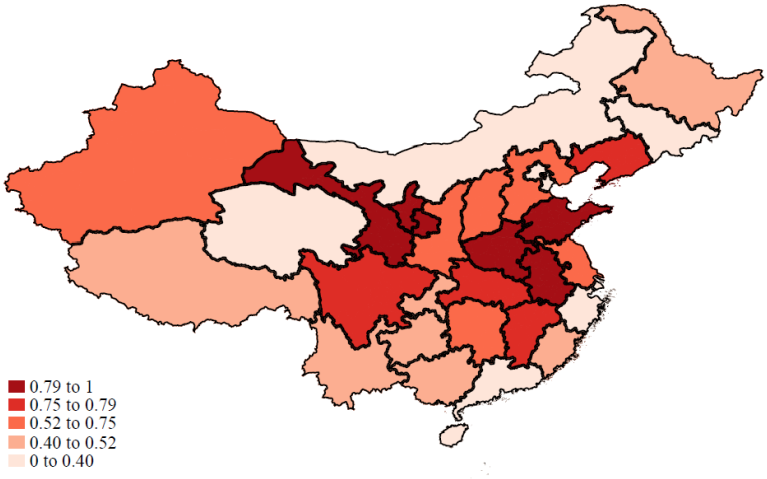
The primary dataset that I use to construct the hukou measure is the 0.095% random-sampled microdata of the Population Census in 2000. The sample contains rich individual-level information including one's hukou registration status and migration history in the last five years, from which I can infer the stringency of a prefecture's hukou system based on the likelihood of an individual obtaining a local hukou after settling in that prefecture. In reality, whether an individual acquires or is granted a local hukou also depends on various individual characteristics. To draw out these effects, I construct the hukou measure as follows. I focus on people who moved to a prefecture other than their birthplace between 1995 and 2000 and estimate the following specification:[14]

$$D_{ind} = \mathbf{C_{ind}}\beta + X_i + \epsilon_{ind}, \tag{1}$$

where D_{ind} is a dummy equal to one if the individual already had a local hukou when the census was taken, $\mathbf{C_{ind}}$ is a vector of observed individual characteristics, and X_i are the prefecture fixed effects that aim to capture regional variation in the hukou granting rate. The idea is similar to the Mincerian wage regression used in, for example, Akerman et al. (2013). After removing various individual heterogeneities that may affect a person's hukou demand or supply, fixed effects are expected to capture the average hukou granting possibilities of a region.

A large number of individual and regional controls are included in $\mathbf{C_{ind}}$. Specifically, $\mathbf{C_{ind}}$ includes a gender dummy, because patriarchy and the absence of land inheritance in China may make it more appealing for women to permanently leave their hometowns. I also control for marital status because married migrants may have a stronger demand for local hukou due to the associated

[14] In the early 1990s, most internal migration was state-planned, guaranteeing local hukou to migrants. I therefore focus on the most recent five years. The raw dataset contains 1,180,111 observations; because most people never migrate, the number of observations in my regressions is 62,289.



Name	Value
The 5 provinces with the most frictions	
Beijing	0
Shanghai	0.02
Qinhai	0.06
Hainan	0.16
Tianjin	0.17

Notes: The measure of hukou frictions for each province, with lighter provinces having more stringent hukou systems in 2000. See the text for details.

Figure 3: Province-level hukou Measure

public services, such as the access to public schools for their children. Moreover, migrants may be unwilling to obtain the local hukou in a destination with low amenity levels. To account for this factor, I control for the differences in the beginning-of-period logged GDP per capita between the migrate-out and migrate-in provinces.[15] Similarly, an ethnicity dummy (Han vs. other ethnic minorities) is added since ethnic minorities are frequently from remote and low-amenity regions, which may translate into a differential demand for local hukou in the destination city relative to the others.

Additionally, $\mathbf{C_{ind}}$ includes the following variables that may influence a migrant's ability to obtain a local hukou: log age ($ln(age)$), education-level dummies,[16] year-of-residency (in the current city) dummies, a migrate-within-province dummy, and a migrate-from-rural-areas dummy. Migrants from the same province, older, with a higher level of education, from urban areas, and who have resided in the destination region for a longer period of time are expected to have an easier time obtaining a local hukou. To allow for the possible nonlinear effects of age, I also include $ln(age)^2$ and $ln(age)^3$ in the regression. To save space, the estimation results are reported in column (1) of Table A3 and discussed in the Appendix C.1. Overall, the estimation results are straightforward and have the expected signs. In addition, the remainder of Section C.1 shows that the estimation results also do not change much when I focus on different migrant subsamples or use provincial fixed effects. The main empirical results of this paper are also robust to the hukou measures constructed using these alternative samples or methods, which I discuss in detail in Section 3.3.

[15] I would prefer to control for differences in GDP per capita at the prefecture-pair level, but there are too many missing values. In 1995, about 25% of prefectures did not report GDP or total population, resulting in about 44% missing values ($1 - 0.75 \times 0.75 \approx 0.44$) in GDP per capita differences between prefecture pairs.

[16] The 2000 census distinguishes 9 levels of education: illiterate, pre-primary education, primary education, lower secondary education, upper secondary education, vocational education, three-year college education, bachelor's level, and master's level and above.

The reported migration inflows are rather small in some prefectures due to the small sample size of the 2000 census microdata. With the large set of controls, some prefecture fixed effects are not identified or are imprecisely estimated. Therefore, I aggregate the hukou measure to the province level by taking a simple average of the estimated prefecture fixed effects by province. Reassuringly, the empirical results of this paper are robust to the non-aggregated hukou measure and alternative aggregation approaches. Section 3.3 presents these results in detail. To facilitate the interpretation, I further normalize the hukou measure to be between zero and one.[17]

The hukou measure is an *inverse* indicator of migration frictions associated with the hukou system: it equals zero if a province has the most stringent hukou policy. Figure 3 visualizes the regional variation in hukou stringency. As expected, Beijing and Shanghai are among the most difficult provinces for migrants to obtain a local hukou.[18]

Comparison with Existing Hukou Indices

Several studies have attempted to develop hukou indices by textually analyzing local governments' laws and regulations. In particular, Wu et al. (2010) calculated the hukou strictness in 2010 *in levels* for a small number of major Chinese cities. Kinnan et al. (2018) created a hukou *reform* index for five provinces between 1992 and 2002. In a manner similar to Kinnan et al. (2018), Fan (2019) and Tian (2021) developed indices of hukou policy *changes*, but with an emphasis on the most recent years, at the prefecture level, and covering all Chinese regions.

The hukou friction measure developed in this paper is a useful addition to this literature. In particular, prior to 2000, there were relatively few changes in hukou legislation. For example, Fan (2019) found that 74% of prefectures had no change in their hukou policies before 2000, and according to Tian (2021), only 19 (6%) prefectures had experienced hukou reform before 2000.[19] Therefore, it is difficult to infer hukou stringency across regions prior to 2000 from the legislative data. Otherwise, one would wrongly conclude that 74% to 94% of Chinese prefectures had the same, and the most restrictive, migration policy in 2000.

Another concern is that the extent to which the frequency of legal changes reflects the strictness of a region's hukou in levels. For example, Beijing and Shanghai have undergone many changes in their hukou policies, but they remain the most difficult cities in which to obtain a local hukou. This is particularly an issue for earlier years, when the hukou-granting rules are not always detailed (Kinnan et al., 2018) and when more regulations and red tapes are "hidden". In this case, it would be more appropriate to infer a region's hukou stringency from the actual hukou-granting probability.

[17] Table A2 presents the summary statistics of both the normalized and non-normalized measures; all empirical results remain robust when using the non-normalized hukou measure. The results are available upon request.

[18] In principle, one could also use this method to construct the hukou measure for 2005 and 2010. Unfortunately, starting in 2005, the National Statistics Office changed the census question on migration and started to define a migrant as "a person who has left the hukou residence". Therefore, if a person reported acquiring a local hukou in the 2005 census, he or she would be classified as a native and would no longer be asked for a detailed migration history.

[19] I thank Yuan Tian for providing this information.

Finally, for the propose of this study, it is important to measure hukou frictions *prior to* trade liberalization to avoid endogeneity concerns, as trade-induced labor demand and supply changes can directly affect a region's migration policy. Indeed, Tian (2021) found that regions facing more export market liberalization enacted more migrant-friendly regulations after China's WTO accession, suggesting hukou reforms are endogenous to trade liberalization. This finding echoes the detailed discussion of hukou policy reforms in Appendix B, namely the timing of regulation announcements may be strategic and correlated with other factors, and that new regulations may sometimes simply affirm existing practices.

In sum, the hukou friction measure developed in this paper is a good addition to the existing indices. If one's research question requires information on hukou frictions prior to 2000, then using the hukou index developed in this paper would be relatively more preferable. If one wants to study hukou policy reforms or hukou regulations in more recent years, it is preferable to use a hukou index developed based on laws and regulations. Appendix C.2 also offers a visual comparison of the different hukou indices. Overall, the comparison suggests that my measure is broadly consistent with the legislation-based measure when it is in levels and when it considers the legislative details, but the legislative-based measures themselves can differ significantly, depending on how they are constructed. Appendix C.3 provides a battery of relevance tests, which show that the hukou measure proposed in this paper accounts for differences in normalized migration shares, both their values in 2000 and their changes from 2000 to 2010, better than the existing measures based on legislative details.

3 Empirical Results

This section presents the empirical evidence of trade-induced spatial labor adjustment and the presence of hukou frictions.

3.1 Main Empirical Results

Given the regional input tariff cuts and the constructed hukou measure, I examine the impact of input liberalization on labor adjustments using the following specifications:

$$\Delta Y_i = \beta_1 \Delta RIT_i + D_p + \mathbf{X_1}\gamma + \epsilon_i, \tag{2}$$

$$\Delta Y_i = \beta_2 \Delta RIT_i + \beta_3 \Delta RIT_i * Hukou_p + D_p + \mathbf{X_2'}\gamma + \epsilon_i, \tag{3}$$

where the second specification explores the heterogeneous regional effect of input tariff reductions depending on the hukou frictions. Here, ΔY_i is the decadal change of the logged value of a regional outcome variable such as employment or total population; β_1 captures the regional effect of input trade liberalization on the variable of interest from 2000-2010, while β_2 and β_3 represent

Table 1: Effect of Input Tariff Cuts on Local Employment

	Main				With Hukou Interactions			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regional input tariff cuts	6.76***	6.92***	5.10***	5.61***	1.35	3.19*	-1.18	-0.31
	(1.72)	(0.94)	(1.65)	(1.91)	(2.62)	(1.67)	(2.02)	(2.84)
Regional input tariff cuts × Hukou					10.88**	7.28**	18.45***	17.71**
					(4.72)	(3.12)	(6.05)	(6.95)
Regional output tariff change		-2.69***	-2.48***	-2.92***		-2.51**	-3.81***	-4.70**
		(0.66)	(0.72)	(0.88)		(1.04)	(1.31)	(2.18)
External tariff change		0.21	0.24	0.35		-0.23	0.04	1.02
		(0.19)	(0.22)	(0.30)		(0.25)	(0.30)	(0.96)
Regional output tariff change × Hukou						0.98	5.34*	6.35
						(1.84)	(3.10)	(4.61)
External tariff change × Hukou						0.82	0.37	-1.43
						(0.55)	(0.47)	(1.75)
Initial employment		-0.02	-0.00	-0.01		-0.01	-0.01	-0.01
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)
Province fixed effects			Yes	Yes			Yes	Yes
Exclude Tibet and Northwest provinces				Yes				Yes
Observations	337	337	337	280	337	337	337	280
R-squared	0.32	0.46	0.66	0.66	0.43	0.51	0.69	0.69

Notes: The dependent variable is the 10-year change in logged prefecture employment. The baseline sample contains 333 prefectures and four directly controlled municipalities. Robust standard errors in parentheses are adjusted for 31 province clusters. Models are weighted by the log of beginning-of-period prefecture employment. *** p<0.01, ** p<0.05, * p<0.1.

the heterogeneous impacts of input tariff reductions depending on hukou frictions; the D_p terms are province fixed effects, and $\mathbf{X}$ represents a set of additional controls. In the main specification, I include regional output tariff and external tariff reductions to control for the effect of increased import competition and improved market access after China's WTO accession, respectively.[20] In addition, I include the pre-liberalization level of the outcome variable to allow for possible mean convergence. $Hukou_p$ is the hukou friction measure; in the second specification, its interactions with external and output tariff reductions are also included. The standard errors are clustered at the provincial level (31 provinces), accounting for the possible covariance between the error terms across prefectures within the same province.

Table 1 presents the results of regressing employment changes on regional input tariff cuts. These regressions are weighted by the log of the beginning-of-period employment. Columns (1)-(5) present the model without interactions. Column (1) shows the OLS results. Column (2) includes the baseline controls, and column (3) further includes the province fixed effects to control for province-specific trends. The estimate of 5.10 in column (3) implies that a 1 percentage point regional input tariff cut was associated with an approximately 5.10 percentage points relative employment increase. The difference between regional input tariff cuts in regions at the 90th and 10th percentiles was 2 percentage points. Evaluated using the estimate in column (3), a prefecture at the 90th percentile experienced a 10.20 percentage points larger employment increase than a prefecture at the 10th

[20]External tariff reductions capture the positive impact of tariff reductions by China's trading partners after its WTO accession; note that most countries had already granted China MFN status before 2001.

percentile. This number may seem substantial, but note that the prefectures that received the most migrants saw their employment increase by more than 60% between 2000 and 2010. According to the estimates in column (3), approximately 23% of the regional variation in employment change can be explained by input liberalization. Consistent with the existing literature, regional output tariff reductions had a negative impact on employment, although of a smaller magnitude than the impact of input tariff cuts. The effects of external tariff reductions and their interaction with the hukou measure have the expected positive sign but are statistically insignificant.

The regions inhabited by Tibetans and Uyghurs are among those with the greatest drop in input tariffs and the greatest rise in employment, as shown in Figures 1 and 2. The significant decrease in input tariffs was driven mainly by tariff reductions in the agricultural sector, as these areas are more specialized in livestock and food processing industries, which use agricultural inputs intensively. However, the observed employment increase may also be influenced by other factors, such as government incentives for Han Chinese to move in. To ensure that the estimation results are not driven by a spurious correlation between employment and trade liberalization in these regions, I repeat the preferred regression in (3) but exclude Tibet and all Northwest prefectures in columns (4).[21] The estimated results do not change much in this case.

Columns (5)-(8) of Table 1 further explore the heterogeneous effect of input liberalization depending on the hukou system. Similar to the case without interactions, I first present the OLS results and then add the additional controls, and finally exclude Tibetan and Uyghur regions. As I normalized the hukou measure to a unit interval, the coefficients on ΔRIT can be interpreted as the impact of input tariff cuts in prefectures with the highest hukou frictions. In the preferred specification in column (7), input tariff reductions had no impact on regional employment in the prefectures with the most stringent hukou policies. In contrast, in regions with the most relaxed hukou systems, a 1 percentage point increase in input tariff cuts led to a 17 percentage points relative increase in employment,[22] much larger than the 5 percentage points average found in column (3). In all cases, the coefficients on the interaction term are positive and statistically significant. For output and external tariff reductions, the interaction terms are mostly insignificant. Calculated based on the specification in column (7), when taking into account both input and output channels, 29% of the regional variation in employment changes can be accounted for by trade liberalization, most of which is explained by the input tariff cuts.[23]

To confirm that it is the spatial reallocation of labor that drives regional changes in employment, I next examine the response of the total population and the working-age (15 to 64 years old) population to tariff changes. If the observed changes in employment are primarily attributable to

[21] Northwest China include prefectures in Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang provinces. Together with Tibet, they account for about 7% of total employment in China.

[22] $18.45 - 1.18 \approx 17$. The sum of $\hat{\beta}_2$ and $\hat{\beta}_3$ is statistically significant unless otherwise stated.

[23] The partial R-squared of regional input tariff cuts, regional output tariff cuts and their interactions with the hukou measure is 0.29. The partial R-squared of regional input tariff cuts and their interaction with the hukou measure is 0.21, while those of output tariff cuts and external tariff cuts are only 0.03 and 0.002, respectively.

Table 2: Effect of Input Tariff Cuts on Other Adjustment Margins

	Total Population		Working Age population		Migrant Inflows		Hukou Population	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regional input tariff cuts (ΔRIT)	5.71***	0.98	4.52**	-2.52	13.96**	-7.25***	-0.23	-4.90***
	(1.22)	(1.61)	(1.74)	(1.98)	(5.65)	(2.37)	(0.83)	(1.56)
Regional input tariff cuts × Hukou		13.16***		20.31***		66.62***		11.33***
		(4.62)		(5.46)		(11.82)		(3.17)
Regional output tariff change	-2.63***	-2.39*	-1.92**	-2.78**	-4.11	-2.76	-3.90***	-3.57*
	(0.64)	(1.39)	(0.77)	(1.24)	(3.03)	(3.17)	(0.69)	(1.99)
Regional output tariff change × Hukou		1.25		4.59		3.54		0.26
		(2.91)		(2.77)		(7.34)		(3.51)
External tariff change	0.25	-0.15	0.26	-0.16	1.70	-0.52	-0.14	-0.26
	(0.25)	(0.28)	(0.25)	(0.25)	(1.38)	(1.43)	(0.12)	(0.22)
External tariff change × Hukou		0.76*		0.80*		4.54**		0.12
		(0.37)		(0.44)		(2.19)		(0.29)
Pre-liberalization Y	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337	337	337	337
R-squared	0.84	0.64	0.58	0.62	0.41	0.45	0.71	0.73

Notes: The dependent variables are the 10-year changes in the logged total population, working age population, migrant inflows from other provinces between 2005 and 2010 and between 1995 and 1990, and population holding local hukou permits (in columns (1)-(2), (3)-(4), (5)-(6) and (7)-(8), respectively). The sample contains 333 prefectures and four directly controlled municipalities. All regressions include the full vector of control variables from column (3) of Table 1; regressions with the interaction terms further include the interaction between the hukou measure and other tariff changes as in column (7) of Table 1. Robust standard errors in parentheses are adjusted for 31 province clusters. The models are weighted by the log of the beginning-of-period prefecture population. *** p<0.01, ** p<0.05, * p<0.1.

intra-regional adjustments, such as variations in unemployment or labor force participation, trade shocks should have no effect on the local population. While if the changes are primarily the result of inter-regional adjustments, the local population's response to trade shocks should be quantitatively similar to the employment response. As shown in columns (1)-(4) of the Table 2, a 1 percentage point increase in regional input tariff cuts leads to increases of 5.71 and 4.52 percentage points in a region's total and working-age populations, respectively. The positive and statistically significant estimated coefficients on input tariff reductions are quantitatively similar to those for employment in both cases, indicating that inter-regional labor reallocation is the primary force behind the regional employment changes.

Compared to indirectly inferring spatial adjustments in labor from regional population changes, it would be preferable to directly examine migration. As the decadal change in net migration inflows is not available, I instead consider the most similar measure reported in the census: the number of migrants from other provinces in the past five years. Because this variable counts migrant inflows in five-year periods, I will compare the number of migrants between 1995 and 2000 with that between 2005 and 2010. As tariff reductions began in 2001, I cannot obtain a significant result if their impact levels off quickly. With this concern in mind, I regress the change in the log 5-year inflow of population from other provinces on regional input tariff reductions, with and without interactions. Because migration is a flow rather than a stock variable, the magnitude of the estimates is much larger. Column (5) in Table 2 shows that a 1 percentage point increase in regional input tariff reductions led to a 13.96 percentage point increases in migrant inflows from

other provinces. Column (6) confirms that input tariff cuts led to larger migrant inflows when the hukou system was less stringent. This finding provides additional support for the notion that regional input tariff cuts increased local employment by attracting labor from other locations and that this effect crucially depended on frictions caused by the hukou system.

In columns (7) and (8) of Table 2, I further examine how the number of individuals holding local hukou (hukou population) in a prefecture responded to input tariff reductions. If local hukou can be obtained without cost, the hukou population should be highly correlated with the total population in a given region and hence react positively to input tariff reductions. The empirical results, however, suggest the contrary: column (7) indicates that on average, reductions in regional tariffs did not cause significant changes in the hukou population. However, in prefectures with less hukou frictions, the hukou population increased in positively affected regions. As shown in column (8), in a prefecture with the freest hukou system, a 1 percentage point increase in regional input tariff cuts led to a 6.43 percentage points increase in the hukou population.[24] The magnitude, however, is only half of the input-liberalization-induced increase in total population (column (2), Table 2). This result implies that hukou frictions are substantial even in regions with the least stringent systems. Because I construct the hukou measure based on the granting probabilities of each region, the positive coefficient on the interaction term provides additional support for its validity.

In sum, the empirical patterns presented in this subsection suggest that input tariff reductions had a large effect on the reallocation of labor across Chinese regions, and this effect was heterogeneous in regions' hukou stringency. Interestingly, I find that, on average, neither the regional output tariff reductions nor the external tariff changes had a significant effect on migrant inflows. The impact of output tariff reductions also did not heterogeneously depend on hukou frictions. This result is intuitive, as stringent hukou policies make it difficult for migrants to settle in but do not directly affect locals' decision to out-migrate. In prefectures with less hukou frictions, greater external tariff reductions attracted more migrant inflows, but the results are less precisely estimated and smaller in magnitude than that of input liberalization. These results, in addition to the estimation results on employment changes, suggest that among various trade shocks associated with China's accession to the WTO, input tariff liberalization seems to have played the dominant role in shaping spatial labor reallocation in China. Therefore, in the remainder of the empirical section, I will focus on the impact of input liberalization and its interaction with hukou frictions. I view the reduced-form exercise as a transparent way to demonstrate the major economic force at play and to guide my model construction. The task of quantifying the general equilibrium effects of tariff reductions and the importance of hukou frictions is relegated to the quantitative section.

[24] $11.33 - 4.90 = 6.43$.

3.2 Confounding Factors to Trade Liberalization

In this and the subsequent subsection, I present a battery of robustness checks of my baseline results. For brevity, I focus on regional employment changes; the results on the other regional adjustments are available upon request.

Hukou Policy Changes

An important concern with my findings is that the hukou policies might also change in response to trade liberalization. If increased labor demand results in local governments relaxing migration policies in prefectures positively affected by trade shocks, my estimates of the interaction between hukou friction and ΔRIT may be biased upwards. To address this concern, I control for changes in hukou policy in column (1) of Table 3. Specifically, I follow Fan (2019) and average his legislative-based hukou index over 2001-2010 and 1997-2000 and use the difference between the two to represent the change in hukou policy from 2000 to 2010. Column (2) further includes the interaction between hukou policy change and the trade shocks. When controlling for changes in hukou policy, point estimates of regional input tariff cuts and the interaction term change very little, confirming the robustness of the baseline results. The full regression results are reported in Table A9 to save space. As shown in Table A9, the liberalization of hukou is indeed positively associated with regional employment increase, but the estimated coefficient is small and only significant at the 10% level. The estimated coefficients on the interaction between changes in hukou policy and trade shocks are all close to zero and insignificant.

Pre-liberalization Employment Changes

To verify that my results are not due to a spurious correlation between the employment trends and trade liberalization, I regress pre-liberalization employment changes (1990-2000) on regional input tariff cuts, using the employment share from 1990 to compute ΔRIT. The industry classification was more aggregated in 1990; hence, I calculate regional tariff cuts based on 61 industries. The 1990 regional employment by sector is missing for some prefectures. To ensure data quality, I work only with prefecture-level cities that have employment information. I also exclude seven processing zones and control for provincial capitals to take into account the rapid growth of processing trade and urbanization during this period. The results are presented in columns (3) and (4) of Table 3. Regional input tariff cuts had no statistically significant impact on pre-liberalization employment, the interaction term is also statistically insignificant and has the opposite sign.[25]

Contemporaneous Shocks

[25]These results are not driven by different levels of industrial aggregation or decreased sample size: when I use the same sample of prefectures, regressing 2000-2010 employment changes on ΔRIT, which is calculated based on the 61 industries, I obtain positive and significant estimates, and they are quantitatively in line with the baseline results (available upon request).

Table 3: Effect of Input Tariff Cuts on Local Employment: Robustness

	Control ΔHukou		ΔEmp, 90-00		Additional Controls		2SLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regional input tariff cuts (ΔRIT)	5.19***	2.06	7.42	21.23	2.78*	-1.88	2.42*	-2.56
	(1.61)	(2.90)	(7.57)	(14.85)	(1.49)	(2.16)	(1.30)	(2.01)
Regional input tariff cuts × Hukou		16.27**		-30.48		14.47**		15.40***
		(6.29)		(21.17)		(6.33)		(5.85)
Changes in state-owned employment shares					-0.01	-0.02	-0.01	-0.02
					(0.01)	(0.02)	(0.01)	(0.02)
Real exchange rate					0.70	0.95	0.79*	1.19*
					(0.44)	(0.88)	(0.42)	(0.72)
Initial share of employment, real estate					5.77*	-7.25	5.66**	-6.76*
					(3.11)	(4.43)	(2.82)	(4.08)
Capital dummy			0.05*	0.12*	0.05**	-0.00	0.05**	0.02
			(0.03)	(0.06)	(0.02)	(0.04)	(0.02)	(0.03)
Pre-liberalization employment trend					0.04	-0.07	0.06	-0.04
					(0.08)	(0.12)	(0.07)	(0.10)
Drop Special Economic Zones			Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap stat.							48.62	17.63
Observations	337	337	280	280	330	330	326	326
R-squared	0.67	0.70	0.29	0.36	0.69	0.73	0.35	0.45

Notes: The sample contains 296 prefectures without Special Economic Zones and four directly controlled municipalities. All regressions include the full vector of control variables from column (3) of Table 1; regressions with the interaction terms further include the interaction between the hukou measure and other tariff changes as in column (7) of Table 1. In columns (1) and (2), I controlled for hukou policy changes between 2000-2010 using the index developed by Fan (2019). In column (8), the interaction between hukou policy change of the three trade shocks are also included. In columns (3) and (4), I replace the dependent variable with the decade-change in employment before liberalization. In columns (7) and (8), I instrument tariff changes with the tariff levels from 1992. In even columns, the interaction terms of the hukou measure and the additional control variables are also included. In most cases, the estimates on the interaction terms and the controls (both the baseline and additional controls) are statistically insignificant, hence they are not reported for the interest of space. Robust standard errors in parentheses are adjusted for province clusters. The models are weighted by the log of the beginning-of-period prefecture employment. *** p<0.01, ** p<0.05, * p<0.1.

Another concern of my findings is that there may be other concurrent policy and economic shocks, in addition to input liberalization, that affect employment adjustment across regions. Specifically, I examine how the pre-liberalization trends, SOE reforms, currency appreciation, housing booms, agglomeration into regional capitals, and the development of special economic zones could affect the results.[26] Column (5) of Table 3 reports the results of regressing employment changes on regional input tariff cuts, taking into account all the above factors. This leads to a lower coefficient on ΔRIT, but it remains positively significant. Column (6) reports the results with the interaction terms: the estimate of the interaction between ΔRIT and the hukou friction is in line with the baseline estimate and is statistically significant at the 5% level. Tables A6 and A7 report the regression results when controlling for one factor at a time without and with the interaction terms, respectively. In all cases, the estimates are very similar to the baseline.

Exogeneity of Trade Liberalization

[26]To control for pre-liberalization trends, I digitalize the 1990 population census tabulation by provinces and compute the logged prefecture-level employment change between 1990 and 2000. I employ the data from the Annual Surveys of Industries (AIS) to construct the regional shifts in the employment share of SOEs between 2000 and 2009 to account for the massive layoffs from the late 1990s that were due to SOE reforms. To control for the impact of currency appreciation, I compute the changes in the regional exchange rate as follows: I first calculate the industry-prefecture-specific change in logged real exchange rates between 2000 and 2010 as a trade-share-weighted average across partner countries; I then average the variable across industries with δ_{is} as the weight. I control for capital fixed effects. Finally, I exclude the 7 prefectures with special economic zones.

Finally, to draw any causal implications of input trade liberalization, the observed tariff changes must be unrelated to counterfactual industry employment growth. Such a correlation may arise if trade policymakers impose smaller tariff cuts to protect weaker industries or if larger industries can lobby for smaller tariff cuts (Grossman and Helpman, 1994). However, this may be less of a concern in the case of China. Viewing WTO membership as a way to lock China onto a path of deepening economic reform and openness, the Chinese government had a greater desire to open than to protect its domestic industries (Woo, 2001). Reassuringly, the correlations between tariff changes and pre-WTO industry employment in both *changes* and *levels* are low and statistically insignificant: the simple correlations are 0.13 and 0.16, respectively.[27] Following Goldberg and Pavcnik (2005), Figure A1 further shows that industries with higher tariffs in 2000 also experienced larger tariff cuts after WTO accession, with a correlation of -0.84. This result suggests that the primary goal of policymakers was to reduce tariff rates in general and to smooth cross-industry variations, thus further ruling out the political economy concerns.

Furthermore, even after rounds of voluntary tariff reductions, the Chinese tariff structure in 2000 remained similar to that in 1992, with a correlation of 0.93.[28] If the pre-liberalization tariffs were highly correlated with the protection structure set a decade earlier while the post-liberalization tariffs were externally set, it is unlikely that tariff reductions between 2000 and 2005 in China would be correlated with counterfactual industry employment changes. To further address the endogeneity concern, I construct an instrument to ΔRIT following the formula of ΔRIT but replacing the 2000-2005 tariff changes with the 1992 tariff levels. Similarly, I also instrument regional output tariff changes using the 1992 tariff levels. Columns (7) and (8) of Table 3 report the two-stage results: a 1 percentage point cut in regional input tariffs results in an average of 5.04 percentage points of employment growth, and 16.27 percentage points more employment in the region with the loosest hukou regimes compared to the region with the strictest. The magnitudes are quantitatively very similar to the baseline estimates.

3.3 Validity of the Hukou Measure

Alternative Measures

The empirical findings of this paper are not sensitive to the specific way in which the hukou measure is constructed. Table 4 presents robustness checks using alternative hukou friction measures. Column (1) utilizes the simple hukou-granting probability without adjusting for individual

[27] If policymakers did allow "stronger" industries to bear larger tariff cuts, industries with higher employment *growth* between 1990 and 2000 would have experienced greater tariff reductions; if large industries lobbied more or were more likely to be protected due to employment concerns, industries with larger employment (in *levels*) in 2000 would have experienced lower tariff cuts.

[28] The year 1992 is the earliest year that Chinese tariff data at the HS6 level are available. On the other hand, the *bound* duties after joining the WTO were largely imposed externally, benchmarking the tariff levels of other WTO members. Unlike many other developing countries, there is no gap between China's *bound* and *applied* duties, and the binding coverage is 100%.

Table 4: Alternative Hukou Friction Measures

	Simple Ratio	Prefecture Measures	Province FE	Population Weighted	Inverse s.d. Weighted	Exclude $mig. < 30$	Hukou Dummy	Family Ties	Rural Origin
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Regional input tariff cuts (ΔRIT)	-0.66	-4.30*	3.46**	2.91***	-2.47**	-2.23	3.85***	-0.20	-0.11
	(2.39)	(2.15)	(1.28)	(1.06)	(1.14)	(2.60)	(1.15)	(2.47)	(3.42)
Regional input tariff cuts × Hukou	15.01**	23.96***	12.56***	12.64***	26.87***	18.43***	6.56***	15.96**	13.91*
	(5.69)	(6.40)	(3.55)	(3.49)	(4.44)	(6.63)	(1.68)	(7.00)	(8.14)
Observations	337	335	337	337	337	337	337	337	337
R-squared	0.69	0.68	0.70	0.69	0.71	0.69	0.69	0.68	0.68

Notes: This table presents the robustness checks on changes in regional employment using alternative hukou friction measures. All regressions include the full vector of control variables from column (7) of Table 1. Robust standard errors in parentheses are adjusted for 31 province clusters. All regressions are weighted by the log of the beginning-of-period prefecture employment. *** p<0.01, ** p<0.05, * p<0.1.

characteristics. Column (2) employs the measure constructed using province fixed effects. Column (3) directly uses the prefecture fixed effects without aggregation. In all circumstances, the coefficients on the interaction terms remain positive and significant and are quantitatively similar to the baseline results, suggesting the robustness of the findings.

It is possible that the fixed effects are not precisely estimated for prefectures with low migration inflows. In columns (4) and (5), I construct alternative hukou indices using prefecture-level averages weighted by the number of migrant inflows and the inverse of the standard errors, respectively. The idea is to assign lower weights to prefectures with low migration inflows or less precisely estimated fixed effects. Note that these indices are more endogenous, as the size of migrant inflows is influenced by hukou restrictions. In column (6), I drop prefectures with fewer than 30 migrants in constructing the hukou measure. The estimation results are robust when using these alternative hukou measures. Finally, in column (7), I replace the hukou measure with a dummy variable equaling to 1 if the baseline hukou measure is below the median. This measure is more robust to measurement errors and unobserved heterogeneity than a continuous measure. The results also remain robust in this case: a 1 percentage point increase in input tariff cuts in regions with above-median relaxed hukou system led to 6 percentage points relative increase in employment compared to regions below the median, which is statistically significant in 1% level.

Local Hukou Demand

Since I do not observe migrants' hukou application decisions, the validity of my hukou measure relies on the assumption that it reflects the stringency of hukou supply rather than demand-side factors. However, the low probability of obtaining a local hukou in a region may simply reflect a lack of demand. For example, if the gains from obtaining a hukou in a particular location are very low, or if migrants expect to move temporarily. This conjecture is theoretically possible, but it is unlikely to occur in reality for a number of reasons. First, for public services for which hukou holders are eligible, such as education or health care, there were few private-sector substitutes in the 1990s, making the demand for local hukou virtually inelastic. Second, about 83% of migrants who moved between 1995 and 2000 were rural migrants. Since urban hukou was much more attractive than rural

hukou at the time, it is hard to imagine these "temporary migrants" did not want to settle in the city permanently if they could.[29] This issue is also partially addressed by including the difference in GDP per capita between the destination and source provinces of migrants in the construction of the hukou measure, since those migrants who move to more developed regions should be more willing to obtain a local hukou. In columns (8) and (9) of Table 4, I use alternative measures of hukou frictions, constructed using subsamples of individuals for whom the hukou demand is more likely to be rigid. In column (8), I focus only on migrants who have local relatives, as these migrants are more likely to want to settle permanently. In column (9), I construct the measure using only migrants from rural areas. As discussed, rural migrants are expected to be more willing to obtain the local (urban) hukou, because in the late 1990s, urban hukou was far more attractive than rural hukou. In both cases, I obtain estimates very similar to the baseline, which again confirms its robustness.

I also perform a placebo test using university students to address this concern. In China, university students can choose to either retain their original hukou or transfer it to their school area. As the transfer is voluntary and free, the hukou-granting ratio among university students should reflect only their willingness to receive a local hukou. This exercise is presented in Appendix D, Table A10. On average, 97% of university students choose to obtain a new hukou. Moreover, there is little variation between provinces, confirming that the demand for hukou is virtually inelastic. In contrast, for rural migrant workers or the entire population, the average granting probabilities are much lower (0.30 and 0.37, respectively) and the regional variations are substantial. I also compare student migrants to recent college graduates as they have more comparable skill levels and location preferences. The differences remain striking: for recent college graduates, the average probability of hukou issuance is nearly 20% lower, while the standard deviation is about 4 times larger. In addition, the hukou measure constructed using the sample of college student migrants correlates little with the baseline hukou friction measures (in contrast, hukou frictions constructed based on rural migrants and university graduates are both significantly correlated with the baseline measure), and there is no evidence that this placebo hukou measure shapes the impact of regional input tariff cuts. In conclusion, although I cannot completely rule out the possibility that the hukou demand may contaminate my results, the evidence presented in this subsection suggests that it is less of a concern.

The Composition of Migration Inflows

Finally, my estimation results may be biased if prefectures receive different migrant mixes. For example, high-skilled workers tend to be more mobile than low-skilled workers. If regions with low hukou frictions happen to attract more skilled workers after trade liberalization, then total

[29] I strictly refer to urban hukou when discussing the supply of and demand for hukou; since collectivization in the 1950s, rural hukou has entailed membership in the village collective and has not been given to migrants (Sun and Fan, 2011). Almost all migration inflows in the periods I examine were towards cities. The divide between urban and rural hukou creates an interesting environment for several areas of study, such as land tenure arrangements, which are not the focus of this paper.

migration may appear to respond more to trade shocks in these regions. Individuals who migrate in order to marry a native may also be more likely to obtain a local hukou, and my baseline results may simply reflect its spurious correlation with hukou restrictions.

To address these concerns, Appendix D, Table A11 examines the impact of input liberalization on different types of working-age migrant inflows: high- and low-skilled migrants, migrants who move for work reasons, and marriage migrants. Both high-skilled and low-skilled workers responded positively to input liberalization, and the effect was stronger in regions with low hukou frictions. Consistent with conjecture, high-skilled workers tend to be more mobile and therefore more responsive to trade shocks and hukou stringencies. However, the magnitudes of the estimated coefficients are comparable to those for low-skilled workers; statistically they are not significantly different from each other. The same is true for working migrants. In short, my results are robust to considering migrants of different skill types and focusing only on individuals who migrate for work reasons. I also find no evidence that marital migration drives the baseline outcomes.

4 A Spatial Model with Migration Frictions

In this section, I propose a quantitative spatial model to further explore the welfare implications of trade liberalization and to quantify the importance of hukou frictions. To keep the quantitative exercises tightly linked to my empirical analysis, I avoid ingredients that have no direct counterparts in the empirical part when constructing the model. In particular, I disallow additional agglomeration forces such as increasing returns to scale or heterogeneous productivity draws of workers across locations. With these purposes in mind, the model builds on Eaton and Kortum (2002, henceforth, EK) and Redding (2016) with both trade and migration frictions. To account for the empirical features, the model also incorporates specific factors, sector heterogeneity, input-output linkages and heterogeneous location preferences.

I make one important deviation from existing quantitative spatial models by allowing for a more realistic elasticity of substitution. With Cobb-Douglas functions, the models would imply that the microstructure of an economy, including the extent of factor reallocation, will play small role in affecting the gains from trade. This could also explain the close-to-zero interaction effect between domestic geography and trade in Fan (2019) and between commuting costs and trade liberalization in Monte et al. (2015), among others.[30] As I show in the next section, in this paper's context, compared to the benchmark case, a model assuming Cobb-Douglas technology across industries not only yields a close-to-zero impact of hukou friction in shaping the aggregate gains of trade, but it also points to the opposite distributional consequences.

[30]None of these papers' main focus is on the interaction effect, hence this does not change their main findings.

4.1 Model Setup

I consider a world with N locations indexed by i, j, and K sectors indexed by s, k, each with a continuum of intermediate varieties indexed by $\nu \in [0,1]$. Three types of inputs are used to produce the varieties: labor, composite goods from all sectors, and a local factor, which I refer to as structures. The production technology of an intermediate variety ν in sector s of location i is a nested CES:

$$q_{is}(\nu) = z_{is}(\nu)\left(\left(\alpha_{is}(L) l_{is}^{\frac{\theta_2^p-1}{\theta_2^p}} + \alpha_{is}(S) s_{is}^{\frac{\theta_2^p-1}{\theta_2^p}}\right)^{\frac{\theta_2^p}{\theta_1^p}\frac{\theta_1^p-1}{\theta_2^p-1}} + \left(\sum_{k\in K}\alpha_{is}(k) Q_{iks}(\nu)^{\frac{\theta_3^p-1}{\theta_3^p}}\right)^{\frac{\theta_3^p}{\theta_1^p}\frac{\theta_1^p-1}{\theta_3^p-1}}\right)^{\frac{\theta_1^p}{\theta_1^p-1}}, \quad (4)$$

where α denotes the share parameters and θ^p the elasticities of substitution. The variable $z_{is}(\nu)$ is the efficiency of producing variety ν, which is distributed Fréchet with a shape parameter θ_s and a level parameter T_{is}. The variables l_{is}, s_{is}, and Q_{iks} are labor, structures, and composite goods from sector k, respectively. The total supply of labor in location i is denoted as L_i, which depends on workers' residential choice (specified later). The total supply of structures is assumed to be fixed and immobile across regions. Rents from structures are redistributed equally to local residents.[31]

To produce the composite good Q_{is}, producers in location i source varieties of sector s from the lowest cost suppliers across locations. Production technologies in each sector are CES with the elasticity of substitution $\sigma_s < \theta_s + 1$. Q_{is} are then used for both consumption and for producing intermediate varieties. Bilateral trade is subject to the iceberg trade cost $\tilde{\tau}_{ijs}$ and ad-valorem tariff t_{ijs}. Denote $\tau_{ijs} = (1 + t_{ijs})\tilde{\tau}_{ijs}$, where $\tau_{ijs} > 1$ for $i \neq j$ and $\tau_{iis} = 1$. Thus, τ_{ijs} units of a variety in sector s must be shipped from location i for one unit to arrive at location j. In the interest of brevity, I ignore tariff revenues for the present and account for them when performing quantitative exercises. Within the empirical context, N locations can be viewed as $N-1$ Chinese regions and the rest of the world. When s refers to a non-tradable sector, $\tilde{\tau}_{ijs} = \infty$ for $i \neq j$.

Consumer preferences over composite goods Q_{is} are CES with share parameter β_s and elasticity of substitution θ_0 . The utility of a worker ω holding a hukou from location h and residing in i depends on her real income, idiosyncratic amenity shocks $a_i(\omega)$, and migration frictions d_{hi}:

$$U_{hi}(\omega) = \frac{a_i(\omega) y_i(\omega)}{d_{hi} P_i}. \quad (5)$$

The idiosyncratic amenity shock $a_i(\omega)$ captures the idea that workers have heterogeneous preferences for living in different locations and are assumed to be drawn from a Fréchet distribution with a shape parameter $\kappa > 1$ and a level parameter A_i.

[31] I implicitly assume that the local government owns structures such as land and natural resources, the rent of which is used to provide public services. Admittedly stylized, I view this as an important aspect of the Chinese economy, as those rents constitute a sizable part of local governments' fiscal revenue. Structures such as land and natural resources are nationally owned in China. Except for offshore petroleum resources, rents from the rest accrue to local governments. Quantitative results based on alternative assumptions on rent allocations do not significantly change the results and are provided as sensitivity checks in Section 5.3.

Living outside one's hukou area is costly. For a worker holding hukou from region h, $d_{hi}P_i$ units of her income have to be spent for one unit of consumption in region i.[32] I assume that d_{hi} consists of both the hukou frictions (H_{hi}) and other types of resettlement costs $\tilde{d}_{hi}$ such that $d_{hi} = H_{hi}\tilde{d}_{hi}$, where $\tilde{d}_{hi} > 1$ for $h \neq i$ and $\tilde{d}_{hh} = 1$. In reality, the hukou system does not discriminate against one's origin among non-locals; therefore, $H_{hi} = H_i > 1$ for $h \neq i$ and $H_{hh} = 1$. Each worker chooses the location that offers her the highest utility and supplies one unit of labor inelastically under perfect competition. The number of workers holding the hukou of a particular location h is assumed to be fixed and is denoted as L_h. Labor is internationally immobile.

4.2 Equilibrium

Given the heterogeneous location preferences and the existence of migration frictions, wages can differ across locations. However, with perfectly competitive labor markets $w_i(\omega)$ must equalize across workers in a given region. The unit input cost to produce a variety in sector s in location i is therefore:

$$c_{is} = \left(\left(\alpha_{is}(L)^{\theta_2^p} w_i^{1-\theta_2^p} + \alpha_{is}(S)^{\theta_2^p} r_i^{1-\theta_2^p} \right)^{\frac{1-\theta_1^p}{1-\theta_2^p}} + \left(\sum_{k \in K} \alpha_{is}(k)^{\theta_3^p} P_{ik}^{1-\theta_3^p} \right)^{\frac{1-\theta_1^p}{1-\theta_3^p}} \right)^{\frac{1}{1-\theta_1^p}}, \tag{6}$$

where w_i is the wage, r_i is the rental rates of structures, and P_{ik} is the price of the composite goods in sector k in location i. From EK, location i's share of expenditure on varieties from sector s, location j is given by:

$$\lambda_{jis} = \frac{T_{js} \left(\tau_{jis} c_{js}\right)^{-\theta_s}}{\sum_{n \in N} T_{ns} \left(\tau_{nis} c_{ns}\right)^{-\theta_s}}. \tag{7}$$

The price of the composite good in sector s, location i therefore is:

$$P_{is} = \eta_s \left(\sum_{j \in N} T_{js} (\tau_{jis} c_{js})^{-\theta_s} \right)^{-\frac{1}{\theta_s}}, \tag{8}$$

where $\eta_s \equiv \Gamma(\frac{\theta_s - \sigma_s + 1}{\theta_s})^{\frac{1}{1-\sigma_s}}$ and $\Gamma(.)$ is a Gamma function. The corresponding local price index is $P_i = (\sum_{s \in K} {\beta_s}^{\theta_0} P_{is}^{1-\theta_0})^{\frac{1}{1-\theta_0}}$. Total revenue in each location equals total expenditure on goods

[32] In reality, the costs of hukou have three main aspects. First, not having a local hukou can entail additional costs of living due to institutional frictions: for instance, one can only take the university entrance examination, be married, or apply for a birth permit or visa application in one's hukou city. Second, workers without a local hukou may have lower bargaining power in the labor market and hence earn lower wages. Finally, one may face a higher bar to access certain products, such as healthcare or education. In the last case, one may pay a higher price to access those goods (if possible), find private alternatives, or return to one's hukou city to consume those goods. In any case, they raise the cost of living for non-hukou holders but require additional (and different) assumptions on how those goods are provided. Having no direct counterpart in the empirical analysis or guidance from real data, iceberg migration costs, given their brevity and straightforward interpretation, seem a reasonable case to consider first. Alternatively, I introduce a public sector following Caliendo et al. (2021) and Fajgelbaum et al. (2015) and assume that migrant workers pay a higher price to access local public goods as a robustness check in Section 5.3.

produced in that location for both consumption and intermediate usage. Thus:

$$R_{is} = \sum_{j \in N} \lambda_{ijs} \left(\tilde{\beta}_{js} Y_j + \sum_{k \in K} \tilde{\alpha}_{jk}(s) R_{jk} \right), \tag{9}$$

where Y_j is the total value added of location j, $\tilde{\beta}_{js}$ and $\tilde{\alpha}_{jk}(s)$ are the equilibrium expenditure shares of s in final consumption and in the production of goods k in location j, respectively.[33] Each worker's income equals her wage plus the transferred rents from structures:

$$Y_i = y_i L_i = w_i L_i + r_i S_i. \tag{10}$$

Equalizing the total wage payment to the total revenue that goes to workers yields the local labor demand:

$$L_i^D = \sum_{s \in K} \tilde{\alpha}_{is}(L) R_{is} / w_i, \tag{11}$$

where $\tilde{\alpha}_{is}(L)$ is the equilibrium expenditure share of labor.[34] Given the distribution of amenities, the probability that a worker with hukou h chooses to live in location i is:

$$\pi_{hi} = \frac{A_i \left(\frac{y_i}{P_i d_{hi}} \right)^{\kappa}}{\sum_{j \in N} A_j \left(\frac{y_j}{P_j d_{hj}} \right)^{\kappa}}. \tag{12}$$

where the shape parameter κ captures the (fundamental) income elasticity of labor supply. Given κ, the relative labor supply to location i (in terms of h hukou holders) increases when the local amenity and real income levels increase and decreases when migration frictions increase. Labor market clearing therefore implies the following:

$$\sum_{s \in K} \tilde{\alpha}_{is}(L) R_{is} / w_i = \sum_{h \in N} \pi_{hi} L_h. \tag{13}$$

Finally, the structure market clearing implies that the equilibrium rental rates can be determined by equating the demand for and supply of structures:

$$\sum_{s \in K} \tilde{\alpha}_{is}(S) R_{is} = S_i r_i. \tag{14}$$

Given the above equations, the equilibrium of the model can be defined as the following.

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[33] Specifically, $\tilde{\beta}_{js} = \frac{\beta_s^{\theta_0} P_{js}^{1-\theta_0}}{\sum_{k \in K} \beta_k^{\theta_0} P_{jk}^{1-\theta_0}}$ and $\tilde{\alpha}_{jk}(s) = \alpha_{jk}(s)^{\theta_3^p} P_{js}^{1-\theta_3^p} \frac{\left(\sum_{s \in K} \alpha_{jk}(s)^{\theta_3^p} P_{js}^{1-\theta_3^p} \right)^{\frac{1-\theta_1^p}{1-\theta_3^p}-1}}{c_{jk}^{1-\theta_1^p}}$.

[34] Specifically, $\tilde{\alpha}_{is}(L) = \frac{\alpha_{is}(L)^{\theta_2^p} w_i^{1-\theta_2^p} c_{is}^{\theta_1^p-1}}{\left(\alpha_{is}(L)^{\theta_2^p} w_i^{1-\theta_2^p} + \alpha_{is}(S)^{\theta_2^p} r_i^{1-\theta_2^p} \right)^{1-\frac{1-\theta_1^p}{1-\theta_2^p}}}$ and $\tilde{\alpha}_{is}(S) = \frac{\alpha_{is}(S)^{\theta_2^p} r_i^{1-\theta_2^p} c_{is}^{\theta_1^p-1}}{\left(\alpha_{is}(L)^{\theta_2^p} w_i^{1-\theta_2^p} + \alpha_{is}(S)^{\theta_2^p} r_i^{1-\theta_2^p} \right)^{1-\frac{1-\theta_1^p}{1-\theta_2^p}}}$.

Definition 1. *Given $\bar{L}_h$, S_{is}, τ_{ijs} and d_{hi}, an equilibrium is a wage vector $\{w_i\}_{i\in N}$, rental prices $\{r_i\}_{i\in N}$, residential choices $\{\pi_{hi}\}_{h\in N,i\in N}$, and goods prices $\{P_{is}\}_{i\in N,s\in K}$ that satisfy equilibrium conditions (6), (7), (8), (9), (10), (12), (13) and (14) for all i, h, s.*

Intuitively, given wage w_i and structure rent r_i, one can solve for the equilibrium prices P_{is} and export shares λ_{ijs} using equations (6), (7) and (8). Labor demand L_i^D and sector output R_{is} can then be solved for using equations (9), (10) and (11). Higher factor prices imply a higher factor supply but a lower factor demand. These two forces work against one another and pin down the equilibrium values of w_i and r_i.

4.3 Equilibrium in Relative Changes

How would the equilibrium change when tariffs or migration frictions change? I proceed as in Dekle et al. (2008) and solve the equilibrium in relative changes. Using the $\hat{x} \equiv x'/x$ notation, where x' is the value of x in the new equilibrium and x is the initial value, the equilibrium equation system (6)-(10), (12), (13)-(14) can be written as the following:

$$\hat{c}_{is} = \left(\tilde{\alpha}_1 \left(\frac{\tilde{\alpha}_{is}(L)}{\tilde{\alpha}_1} \hat{w}_i^{1-\theta_2^p} + \frac{\tilde{\alpha}_{is}(S)}{\tilde{\alpha}_1} \hat{r}_i^{1-\theta_2^p} \right)^{\frac{1-\theta_1^p}{1-\theta_2^p}} + (1-\tilde{\alpha}_1) \left(\sum_{k\in K} \frac{\tilde{\alpha}_{is}(k)}{1-\tilde{\alpha}_1} \hat{P}_{ik}^{1-\theta_3^p} \right)^{\frac{1-\theta_1^p}{1-\theta_3^p}} \right)^{\frac{1}{1-\theta_1^p}}; \tag{15}$$

$$\hat{\lambda}_{jis} = \left(\frac{\hat{\tau}_{jis}\hat{c}_{js}}{\hat{P}_{is}} \right)^{-\theta_s}; \tag{16}$$

$$\hat{P}_{is} = \left(\sum_{j\in N} \lambda_{jis} \left(\hat{\tau}_{jis}\hat{c}_{js} \right)^{-\theta_s} \right)^{-\frac{1}{\theta_s}}; \tag{17}$$

$$R'_{is} = \sum_{j\in N} \lambda_{ijs}\hat{\lambda}_{ijs}(\tilde{\beta}_s\hat{\tilde{\beta}}_s Y'_j + \sum_{k\in K} \tilde{\alpha}_{jk}(s)\hat{\tilde{\alpha}}_{jk}(s)R'_{jk}) \tag{18}$$

$$Y'_i = w_i L_i \hat{w}_i \hat{L}_i + r_i S_i \hat{r}_i; \tag{19}$$

$$\hat{\pi}_{hi} = \frac{\left(\hat{y}_i / \hat{P}_i \hat{d}_{hi} \right)^{\kappa}}{\sum_{n\in N} \pi_{hn} \left(\hat{y}_n / \hat{P}_n \hat{d}_{hn} \right)^{\kappa}}; \tag{20}$$

$$\frac{\sum_{s\in K} L_{is}\hat{\tilde{\alpha}}_{is}(L)\hat{R}_{is}}{\hat{w}_i} = \sum_{h\in N} \hat{\pi}_{hi} L_{hi}; \tag{21}$$

$$\hat{r}_i = \sum_{s\in K} \frac{\tilde{\alpha}_{is}(S) R_{is} \hat{\tilde{\alpha}}_{is}(S) \hat{R}_{is}}{\sum_{k\in K} \tilde{\alpha}_{ik}(S) R_{ik}}, \tag{22}$$

where $\tilde{\alpha}_1 = \tilde{\alpha}_{is}(L) + \tilde{\alpha}_{is}(S)$, $\hat{y}_i = \frac{Y'_i}{Y_i \hat{L}_i}$, $\hat{P}_i = \left(\sum_{s\in K} \tilde{\beta}_{is} \left(\hat{P}_{is} \right)^{1-\theta_0} \right)^{\frac{1}{1-\theta_0}}$, and $L_{hi} \equiv \pi_{hi} L_h$. Note that the relative changes in the expenditure shares, $\hat{\tilde{\beta}}$ and $\hat{\tilde{\alpha}}$, change endogenously in response to

shocks.[35] Focusing on relative changes allows me to perform policy experiments without knowing the parameters that are difficult to estimate, namely the productivity, amenities and transportation costs.

4.4 Gains from Trade and the Implication of (Deviating from) Cobb-Douglas

Using equations (5) and (12), the expected utility for workers holding hukou h can be written as:

$$U_h = \Gamma(1-\frac{1}{\kappa})\left(\sum_{j\in N} A_j\left(\frac{y_j}{P_j d_{hj}}\right)^{\kappa}\right)^{\frac{1}{\kappa}}. \tag{23}$$

Intuitively, the expected utility depends positively on real income $\frac{y_j}{P_j}$ and the general amenity level A_j and negatively on migration frictions d_{hj}. With a Fréchet distribution, the expected utility of workers holding hukou h conditional on living in location j is the same across all locations. A better location directly raises the utility that a worker can derive from that location, but it also attracts workers with lower amenity draws. In equilibrium these two effects exactly cancel out each other.

Given a trade shock (holding migration frictions constant), the change in expected utility for workers with hukou h can be decomposed to regional gains from trade plus a reallocation term:

$$\hat{U}_h = \underbrace{\hat{y}_h/\hat{P}_h}_{regional\ gains\ from\ trade} \times \underbrace{\hat{\pi}_{hh}^{\frac{-1}{\kappa}}}_{reallocation\ gains}. \tag{24}$$

In the case without internal migration, the individuals' gains from trade are exactly equal to the regional gains from trade of their hukou regions, that is, local real income changes in h. While if workers are perfectly mobile, the redistribution term will adjust so that in equilibrium, the gains from trade are the same for workers from different hukou regions.

To gain intuition on why the Cobb-Douglas model tends to predict a small role for labor allocation in affecting the gains from trade, it is useful to write down the equilibrium in relative changes when both production and consumption feature Cobb-Douglas. I present this system of equations in Appendix $E.1$. An important observation is that, unlike CES, all share parameters are constant under Cobb-Douglas. In this case, starting from two different initial equilibriums, the extent to which the impact of the same trade shock will be different essentially depends only on the values of λ_{ijs}, per capita revenue R_{is}/L_i and π_{hi}. Unless the reduction of hukou frictions leads to very large changes in these parameters, the difference in regional real income changes will be small compared

[35] The expressions of the share parameters are $\hat{\tilde{\beta}}_{js} = \frac{\hat{P}_{js}^{1-\theta_0}}{\sum_{k\in K}\tilde{\beta}_{jk}\hat{P}_{jk}^{1-\theta_0}}$, $\hat{\tilde{\alpha}}_{is}(S) = \frac{\hat{r}_i^{1-\theta_2^p}\hat{c}_{is}^{\theta_1^p-1}}{\left(\frac{\hat{w}_i^{1-\theta_2^p}\tilde{\alpha}_{is}(L)}{\tilde{\alpha}_{is}(S)+\tilde{\alpha}_{is}(L)}+\frac{\hat{r}_i^{1-\theta_2^p}\tilde{\alpha}_{is}(S)}{\tilde{\alpha}_{is}(S)+\tilde{\alpha}_{is}(L)}\right)^{1-\frac{1-\theta_1^p}{1-\theta_2^p}}}$,

$\hat{\tilde{\alpha}}_{is}(L) = \frac{\hat{w}_i^{1-\theta_2^p}\hat{c}_{is}^{\theta_1^p-1}}{\left(\frac{\hat{w}_i^{1-\theta_2^p}\tilde{\alpha}_{is}(L)}{\tilde{\alpha}_{is}(S)+\tilde{\alpha}_{is}(L)}+\frac{\hat{r}_i^{1-\theta_2^p}\tilde{\alpha}_{is}(S)}{\tilde{\alpha}_{is}(S)+\tilde{\alpha}_{is}(L)}\right)^{1-\frac{1-\theta_1^p}{1-\theta_2^p}}}$ and $\hat{\tilde{\alpha}}_{jk}(s) = \frac{\hat{P}_{js}^{1-\theta_3^p}\hat{c}_{jk}^{\theta_1^p-1}}{\left(\sum_{s\in K}\frac{\tilde{\alpha}_{jk}(s)\hat{P}_{js}^{1-\theta_3^p}}{\sum_{s\in K}\tilde{\alpha}_{jk}(s)}\right)^{1-\frac{1-\theta_1^p}{1-\theta_3^p}}}$

to the real income changes themselves.

Consider a model-based difference-in-difference counterfactual exercise: first calculate the effect of tariff cuts starting from the observed initial equilibrium (first scenario, denote as dE), and then calculate the effect of the same trade shock but starting from the equilibrium where the hukou restrictions are removed (second scenario, denote as dE'). By comparing these two changes (with the difference denoted by Δ), one can see the extent to which migration frictions affect the welfare gains from trade. Using the $\dot{x} \equiv dlog(x)$ notation, the log changes in welfare can be written as:

$$\dot{U}_h = \sum_{i \in N} \pi_{hi} (\frac{\dot{y}_i}{P_i}). \tag{25}$$

Therefore, the population-weighted average of log welfare changes at the national level is:

$$\dot{U} \equiv \sum_{h \in N} \frac{L_h}{L} \dot{U}_h = \sum_{i \in N} \frac{L_i}{L} (\frac{\dot{y}_i}{P_i}). \tag{26}$$

When $\Delta(\frac{\dot{y}_i}{P_i})$ is small compared to $\Delta\pi_{hi}$ and $(\frac{\dot{y}_i}{P_i})$, the difference regarding welfare changes for individuals holding hukou from h between dE' and dE, $\Delta\dot{U}$, is approximately equal to:

$$\Delta\dot{U} \approx \sum_{i \in N} \frac{\Delta L_i}{L} (\frac{\dot{y}_i}{P_i}). \tag{27}$$

Note that $\sum_{i \in N} \frac{\Delta L_i}{L} = 0$ since labor supply at the national level is exogenous. Therefore, the sign of $\Delta\dot{U}$ is the same as $corr(\Delta L_i, (\frac{\dot{y}_i}{P_i}))$. If the regions positively affected by trade shocks tend to be regions with high hukou restrictions, i.e. $corr(\Delta L_i, (\frac{\dot{y}_i}{P_i})) > 0$, under the Cobb-Douglas assumptions the model is likely to predict that the removal of the hukou restrictions will increase the gains from trade. If $corr(\Delta L_i, (\frac{\dot{y}_i}{P_i})) < 0$, the model is likely to predict the opposite.

On whether the distributional effects of trade will be amplified or diminished when the hukou restrictions are removed, one can show that the standard deviation (SD) of the individual welfare changes can be expressed as the following:

$$SD = \left[\sum_{h \in N} \frac{L_h}{L} (\dot{U}_h^2 - \dot{U}^2) \right]^{\frac{1}{2}}. \tag{28}$$

with

$$\dot{U}_h = \sum_{i \in N} \pi_{hi} (\frac{\dot{y}_i}{P_i}), \qquad \dot{U} = \sum_{i \in N} \frac{L_i}{L} (\frac{\dot{y}_i}{P_i}). \tag{29}$$

Since both L and L_h are exogenously given, when the regional real income does not change much in the first and second counterfactual scenarios, the variation of SD depends mainly on the extent to which π_{hi} differs from the overall labor distribution, $\frac{L_i}{L}$, in the initial equilibrium of the first and

the second scenarios. The more restrictive the hukou system is, the larger the share of individuals holding hukou from a certain region h that remain in their region, and therefore the greater the difference between the spatial distribution of labor of a given region (in terms of hukou) and the spatial distribution of labor nationwide. When the hukou system is relaxed, π_{hi} adjusts in the opposite direction and depends less on h, becoming more similar to $\frac{L_i}{L}$. Therefore, under the Cobb-Douglas assumptions, the model is most likely to predict that the removal of the hukou restrictions dampens the distributional consequence of trade.

Appendix $E.1$ contains a more detailed discussion and the associated mathematical derivations. In addition, I also provided numerical examples to support the above observation. Overall, I find that the claim that freer migration increases the gains from trade and weakens the distributional impact holds over a large range of trade and migration cost reduction values, and the counterfactual equilibrium changes are consistent with the theoretical analysis.

5 Quantifying the Regional Effects of Trade Liberalization

In this section, I calibrate the model in relative changes to the pre-liberalization year 2000 to quantify the general equilibrium effects of tariff reductions and the role of hukou frictions in shaping these effects. The data needed are tariff changes, cost shares, consumption shares, beginning-of-period sector output R_{is}, bilateral trade shares λ_{ijs}, bilateral labor flows L_{hi}, elasticities θ_s, κ, and hukou frictions.

5.1 Taking the Model to the Data

I calibrate the model to 31 regions, including 30 Chinese provinces and a constructed rest of the world, and 71 industries (using the same industry classification as in Section 2). Tibet is also excluded from the analysis due to a lack of data on trade flows between Tibet and other Chinese regions. Ideally, the model is preferably calibrated at the prefecture-level for the comparison with the empirical analysis. Unfortunately, trade and migration flow data for 2000 at the prefectural level are not available. Therefore, I conduct the main quantitative analysis at the provincial level and provide the analysis at the prefectural level as a robustness check.

All variables except for θ, κ, and hukou frictions can be directly observed from the data. A summary of the sources and construction of variables are provided in Appendix E.2. In particular, the income elasticity of labor supply $\kappa = 2.54$ is taken from Tombe and Zhu (2019). I estimate the sectoral trade elasticity θ_s following Caliendo and Parro (2015), and the results are reported in Appendix E.3. Following Baqaee and Farhi (2019), I set the elasticity of substitution across industries $\theta_3 = 0.2$, that between value-added and intermediates $\theta_1 = 0.5$, among primary factors $\theta_2 = 0.5$, and in consumption $\theta_0 = 0.9$. These elasticities are broadly consistent with the estimates of Atalay (2017), Boehm et al. (2019), Herrendorf et al. (2013), and Oberfield and Raval (2014).

Although it is preferable to estimate these elasticities in the same empirical context, it is beyond the scope of this paper. As shown in Section 5.3, the quantitative results are robust to the use of other elasticity parameter values.[36]

I use the ratio-type estimation following Caliendo and Parro (2015) and Head and Ries (2001) to parameterize the migration costs associated with the hukou system. Consider two regions, i and h. Take the ratio of workers with hukou h living in i to workers with hukou h living in h, and vice versa. Using equation (12) to calculate each expression and then multiplying them, I obtain:

$$\frac{L_{hi}}{L_{hh}}\frac{L_{ih}}{L_{ii}} = (d_{ih}d_{hi})^{-\kappa}. \tag{30}$$

Amenities, prices, and income terms are canceled out, and I end up with a relation between bilateral labor flows and migration costs. I parameterize d_{hi} with the following functional form:

$$-\ln d_{hi} = \psi_0 + \psi_l \ln Hukou_i + \psi_d \ln dist_{hi} + \psi_{cb} D_{c.b} + D_{r_h r_i} + \epsilon_{hi}, \tag{31}$$

where $Hukou_i$ is the hukou measure used for empirical analysis in Section 2 (before normalization), $dist_{hi}$ is the great-circle distance between provincial capitals, and $D_{c.border}$ is a dummy indicating whether provinces h and i share a common border and $D_{r_h r_i}$ is region-pair fixed effects that control for migration frictions due to regional differences in culture and economic development.[37] Taking the logarithms of equation (30) and using equation (31) to substitute for $\ln d_{hi}$, I obtain:

$$\ln(\frac{L_{hi}}{L_{hh}}\frac{L_{ih}}{L_{ii}}) = 2\kappa\psi_0 + \kappa\psi_l \ln Hukou_i + \kappa\psi_l \ln Hukou_h + 2\kappa\psi_d \ln dist_{hi} + 2\kappa\psi_{cb} D_{c.b} + 2\kappa D_{r_h r_i} + \tilde{\epsilon}_{hi}, \tag{32}$$

where $\tilde{\epsilon}_{hi} = \kappa(\epsilon_{hi} + \epsilon_{ih})$.

To compute the initial distribution L_{hi}, I obtain the number of individuals holding hukou from province h and living in j from the National Tabulation of the 2000 population census. Note that migrants who obtained hukou in j should still be considered as people from h. Therefore, I use the micro-sample of the 2000 Census and calculate the proportion of non-local-born migrants from birth location h to location i from 1995 to 2000 and obtain hukou in i.[38] This group of individuals is then also counted in the migration flows from h to i. The L_{hi} after this correction is consistent with the way the hukou measure is constructed. The population in the rest of the world comes from

[36] The share parameters, as suggested by the Chinese IO tables, vary significantly from year to year. From 2002 to 2007, the consumption shares of most industries changed by more than 100%, and the production shares across labor and specific factors vary less, but for most industries they still changed by more than 50%. Since the share parameters vary considerably over such a short period of time, the deviation from the Cobb-Douglas assumption is also reasonable from the data perspective. Overall, existing empirical evidence suggests that these elasticities are all less than one.

[37] There are eight economic regions in China: the northeast (Liaoning, Jilin, and Heilongjiang), the northern coast (Beijing, Tianjin, Hebei, and Shandong), the eastern coast (Shanghai, Jiangsu, and Zhejiang), the southern coast (Fujian, Guangdong, and Hainan), the Yellow River region (Shaanxi, Shanxi, Henan, and Inner Mongolia), the Yangtze River region (Hubei, Hunan, Jiangxi, and Anhui), the southwest (Yunnan, Guizhou, Sichuan, Chongqing, and Guangxi) and the northwest (Gansu, Qinghai, Ningxia, Tibet, and Xinjiang).

[38] More than 90% of these people also lived in province h five years ago.

the World Bank.[39] I set the migration between Chinese provinces and the rest of the world to zero.

I estimate equation (32) using OLS and obtain an R-squared of 0.64 and $\kappa\hat{\psi}_l$ of 0.33, which is positive and significant at the 1% level.[40] When $\kappa = 2.54$, the elasticity of migration costs with respect to hukou is $\psi_l = 0.13$. The median hukou measure estimated in the data is 0.20, which suggests a hukou-related migration cost $H_i = 1.23$, i.e., the additional cost of living for migrant workers in a province with median hukou frictions is approximately 23% of their income.[41] Using the Chinese Household Income Project Survey (CHIPS), Chen et al. (2010) find that if hukou restrictions were removed in 2002, the average consumption of migrants would have risen by 20.8% after controlling for the impact of remittances. Although not directly comparable, my estimates are quantitatively in line with their result. The estimation results change little when I include further controls such as ethnic and industry similarities across locations. These additional results are presented in Appendix C.3.

5.2 Quantitative Exercises

I quantify the economic effects of tariff reductions and the role of hukou frictions by performing two different but equally informative counterfactual exercises. In the first counterfactual, I introduce Chinese tariff changes from 2000 to 2005 and fix hukou frictions at their 2000 level. In the second counterfactual, I measure the impact of tariff reductions when hukou frictions are eliminated. To this end, I first calculate the effects of abolishing the hukou system and then evaluate the effects of tariff reductions starting from this new equilibrium. By comparing the results of the two counterfactuals, I am able to quantify the relevance of hukou frictions in shaping the impact of trade liberalization. The second exercise also sheds light on the importance of the hukou system in directly affecting the welfare of workers from different hukou locations.

Regional Effects of Tariff Reductions

I first evaluate the validity of the theoretical framework by comparing the simulated provincial employment changes with the actual data. As shown in Figure A5, the simulated regional employment changes qualitatively match well with the observed employment changes, with a correlation of 0.81 and an R-squared of 0.66. Table 5 presents the regional effects of tariff reductions when hukou frictions are left unchanged. I set the nominal wage of the rest of the world as the numeraire. The provinces with the largest increases in employment are Beijing, Shanghai, and Tianjin, with Beijing and Shanghai experiencing employment increases of 0.65% and 0.42%, respectively. The provinces with the largest migration outflows are all inland provinces closely located to the above-mentioned booming areas. When the former experiences an increase in labor demand, it is intuitive

[39] I implicitly assume that the initial distribution of labor is the same as the distribution of population.

[40] The estimation result is also reported in Table column (1) of A4, Appendix C.3.

[41] H_i for the median province is calculated as $\frac{1}{0.2^{0.33/2.54}} \approx 1.23$. That is, migrants are willing to forgo $1 - \frac{1}{1.23} \approx 19\%$ of their income to obtain a local hukou.

Table 5: Regional Adjustments to Tariff Reductions

Province	(1) Employment	(2) Real Wage	(3) GDP	(4) Price	(5) Exports	(6) Imports	(7) Welfare
with the largest emp. increase							
Beijing	0.65%	1.97%	2.51%	-1.82%	8.70%	3.78%	1.85%
Shanghai	0.42%	1.71%	2.00%	-1.63%	6.25%	4.51%	1.58%
Tianjin	0.20%	1.51%	1.67%	-1.75%	7.26%	5.13%	1.48%
with the largest emp. decrease							
Sichuan	-0.07%	0.52%	0.43%	-1.34%	2.75%	5.32%	0.60%
Anhui	-0.11%	0.54%	0.43%	-1.31%	2.76%	5.65%	0.67%
Jiangxi	-0.11%	0.41%	0.30%	-1.22%	2.26%	5.94%	0.54%
Weighted average							0.72%
Standard deviation							0.26%

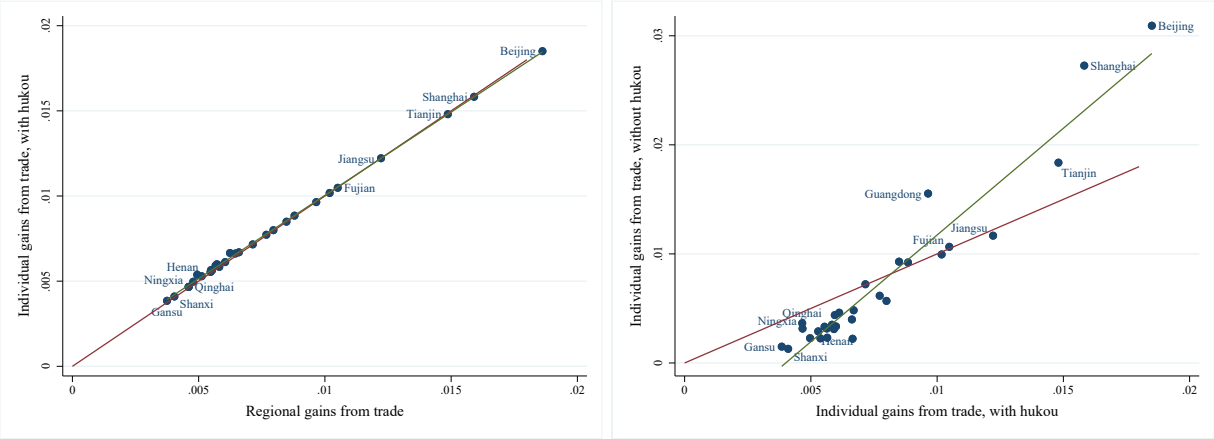
Notes: This table presents the counterfactual percentage changes in regional employment, real wage, real GDP (total value added divided by local consumption price index), consumption price index, exports, and imports when the Chinese tariff structure changed from its 2000 to its 2005 level, holding hukou frictions constant. The nominal wage of the constructed rest of the world is the numeraire.

that workers are attracted away from these regions.

In terms of magnitude, the changes in employment predicted by the model are quiet small compared to the data. One potential explanation is that the quantitative spatial model used in this paper is static so there are no trade-induced dynamics, and I additionally disallow various agglomeration forces. Moreover, indirect effects of trade liberalization, such as trade-induced technology adoption, could contribute to the observed regional employment changes and their impacts are reflected in the empirical estimations, but not in the quantitative results. In this sense, one can interpret the simulated employment changes as lower-bound results.

Columns (2)-(6) of Table 5 presents the model-implied changes in other margins. Intuitively, regions that benefit more from trade liberalization experience greater growth in real wages, real GDP, trade and greater decline in local consumption index. Moreover, most of the gains from trade are from the lowered local consumption indices. Column (7) presents the change in welfare. All regions of China benefit from the tariff reductions, but the distribution of the benefits is uneven. People with hukou from Beijing and Shanghai hukou experience welfare improvements of 1.85% and 1.58%, respectively, while individuals holding hukou from Jiangxi gain only 0.54% – approximately 70% less. The hukou-population-weighted average welfare increase is 0.72%, with the standard deviation being 0.26%.[42]

[42]The gains from trade and the model-predicted change in trade flows is comparable to other quantitative papers utilizing similar models (e.g. Caliendo and Parro (2015)), but low compared to the observed GDP and trade growth in China. There can be many reasons for this disconnect. First, the model does not consider dynamic effects of trade liberalization, therefore, the model cannot capture the change in the long-term growth rate of GDP. Second, the model does not take into account is the increase in labor supply in cities due to demographic changes and urbanization. Before China's economic reforms, a large amount of semi-idle labor in rural areas was categorized as employment of the agricultural sector. This labor force flooded into the cities since the late 1990s and began working in the manufacturing and service sectors. Together with the demographic changes, employment in manufacturing and services increased by about 40% between 2000 and 2010. This transition, not necessarily caused by trade liberalization, can contribute to a sizable increase in aggregate GDP and trade flows observed in the data.



Notes: This left panel of this figure plots individual welfare changes in terms of hukou province (individual gains from trade) against the changes in provincial real income per capita (i.e., regional gains from trade). This left panel plots individuals' welfare changes from tariff reductions in terms of hukou provinces (individual gains from trade) with hukou abolition against the changes without hukou abolition. The green lines are the linear fits, and the red lines are the 45 degree line in both panels.

Figure 4: Individual and Regional Gains from Trade, with and without Hukou

To explore the extent to which internal migration has alleviated the uneven welfare gains, the left panel of Figure 4 plots individual welfare changes in terms of their hukou (individual gains from trade) against the changes in provincial real income per capita (regional gains from trade). The relationship is strikingly linear, with the data points lying around the 45 degree reference line. This result suggests that the redistribution of wealth via migration is limited: while we observe large increases in real income, most of the gains accrue to locals due to the high costs of migration.

Effects of Tariff Reductions Given the Elimination of Hukou Frictions

Next, I examine the extent to which the effects of tariff reductions can be influenced by the elimination of hukou frictions. To do so, I first use the hukou frictions estimated in the previous subsection to quantify the regional effect of abolishing the hukou system. Table 6 presents the associated regional adjustments. Beijing, Shanghai, and Guangdong are the top migrant-receiving provinces, with employment increases of more than 10%. Jiangxi, Anhui, and Sichuan are the provinces with the largest migrant outflows. The large migrant outflows in Anhui are likely (among other factors) driven by its geographic proximity to Shanghai, while the outflows in other provinces are likely due to their proximity to Guangdong. In expanding provinces, increased labor supply lowers real wages and increases local GDP. Because of the increased economic size, more intermediates are sourced locally and the local price index falls.

Although increased regional employment harms local hukou holders by pushing up rents and lowering wages, relaxations in the hukou system make it easier for individuals to move to provinces where they have higher amenity draws, which always improves welfare. Therefore, while individuals holding hukou from provinces with net migrant outflows unambiguously benefit from hukou reforms,

Table 6: Regional Effects of Hukou Abolition

Province	(1) Employment	(2) Real Wage	(3) GDP	(4) Price	(5) Exports	(6) Imports	(7) Welfare
with the largest emp. increase							
Beijing	26.51%	-10.58%	15.83%	-16.16%	8.91%	-17.71%	-7.99%
Shanghai	23.75%	-9.70%	14.47%	-15.96%	0.95%	-18.00%	-6.97%
Guangdong	12.23%	-5.05%	8.13%	-15.37%	-5.49%	-16.59%	-3.34%
with the largest emp. decrease							
Sichuan	-5.33%	2.89%	-3.37%	-13.31%	-23.76%	-13.12%	4.53%
Anhui	-5.43%	3.34%	-2.91%	-13.70%	-21.52%	-14.25%	5.07%
Jiangxi	-5.98%	2.78%	-4.06%	-13.55%	-23.73%	-13.95%	4.75%
Weighted average							1.70%
Standard deviation							2.37%

Notes: This table presents the counterfactual percentage changes in regional employment, real wage, real GDP (total value added divided by local consumption price index), consumption price index, exports, imports, and hukou population's welfare when hukou frictions are reduced to zero in all provinces, holding tariffs constant. The nominal wage of the constructed rest of the world is the numeraire.

those with hukou from migrant-receiving provinces may not necessarily lose. As shown in the last column of Table 6, the top-expanding provinces' hukou holders experience significant welfare losses. However, among the 14 provinces that experience employment increases, the hukou holders' welfare decreases in only six. The hukou-population-weighted average welfare increases by 1.70%, which is significantly higher than the gains from tariff reductions.

Starting from this post-hukou-abolition equilibrium, I repeat the first quantitative exercise with the same tariff changes to evaluate the extent to which hukou frictions shape the gains from trade. Table 7 presents the results. A comparison with Table 5 makes it clear that regional employment reacts strongly to trade shocks when hukou frictions are eliminated: on average, the employment response almost quadrupled. The rich substitution pattern results in rich wage and income responses. Positive migration flows are associated with a fall in real wages and an increase in factor prices, with the latter effect dominating and resulting in a rise in real income. In contrast, in regions with migration outflows, the real wage in general increases while the real factor return declines.

Compared to the case with hukou frictions, the aggregated welfare improvement from trade liberalization decreases by 18%, from 0.72% to 0.59%. This rather surprising result is due to the interplay of two forces. On the one hand, freer migration implies greater gains from trade through efficient labor reallocation; on the other hand, depending on the interplay between migration and trade costs, free migration may lead to too uneven regional development, undermining the aggregate gains from trade. The latter point can be best seen by comparing the trade response reported in Table 7 to that reported in Table 5: as labor and other factors of production are complements, When a region like Beijing experiences a large inflow of labor, this simultaneously means that the specific factor become relatively scarce. Therefore, the gains from trade in Beijing may not be enough to compensate the relative loss in other regions with net migration outflows. The later

Table 7: Regional Adjustments to Tariff Reductions, without Hukou Frictions

Province	(1) Employment	(2) Real Wage	(3) GDP	(4) Price	(5) Exports	(6) Imports	(7) Welfare
with the largest emp. increase							
Beijing	2.70%	-1.94%	4.42%	-4.38%	2.58%	1.18%	3.09%
Shanghai	2.10%	-2.12%	3.63%	-4.19%	-1.79%	1.91%	2.73%
Guangdong	0.86%	-1.37%	1.77%	-4.02%	-0.53%	5.54%	1.55%
with the largest emp. decrease							
Hunan	-0.36%	1.03%	0.07%	-3.85%	1.86%	3.05%	0.31%
Jiangxi	-0.51%	1.14%	-0.18%	-3.77%	-1.48%	3.50%	0.23%
Anhui	-0.55%	1.16%	-0.07%	-3.91%	-0.68%	3.22%	0.22%
Weighted average							0.59%
Standard deviation							0.52%

Notes: This table presents the counterfactual percentage changes in regional employment, real wage, real GDP (total value added divided by local consumption price index), consumption price index, exports, and imports when the Chinese tariff structure changed from its 2000 to its 2005 level after eliminating hukou frictions. The nominal wage of the constructed rest of the world is the numeraire.

effect dominates in the Chinese context and overshadows the benefits of trade liberalization.

The standard deviation of welfare gains doubled compared to the case with hukou frictions, from 0.26% to 0.52%. The right panel of Figure 4 plots individual gains from tariff reductions without hukou frictions relative to those with hukou frictions. The plot is steeper than the 45 degree line, suggesting that the elimination of hukou frictions amplifies the negative distributional effects of trade. This result is somewhat surprising, as one might expect that freer migration leads to greater labor adjustments across regions, which narrows the spatial welfare gap and leads to more evenly distributed gains.

To better understand the mechanisms behind the increase in spatial inequality, I decompose regional welfare changes into regional gains from trade and gains from redistribution according to equation (24), for the cases with and without hukou frictions in Figure 5. The reallocation gains are greater in almost all regions after the removal of hukou system, suggesting a more balanced distribution of trade gains across different hukou holders due to the lowered migration costs. However, with freer labor mobility, the regional gains from trade (i.e. changes in real income) also become more uneven across regions. The latter effect dominates, leading to greater negative distributional consequences of trade liberalization in the absence of hukou restrictions.

5.3 Comparison with the Cobb-Douglas Model and Sensitivity Analyses

As discussed in the previous section, it is essential to deviate from the Cobb-Douglas production function to investigate the interaction between trade and domestic frictions. Next, I demonstrate this point quantitatively. Table 8 presents the counterfactual changes in response to trade shocks with and without hukou frictions, for both the baseline model and a model where production and

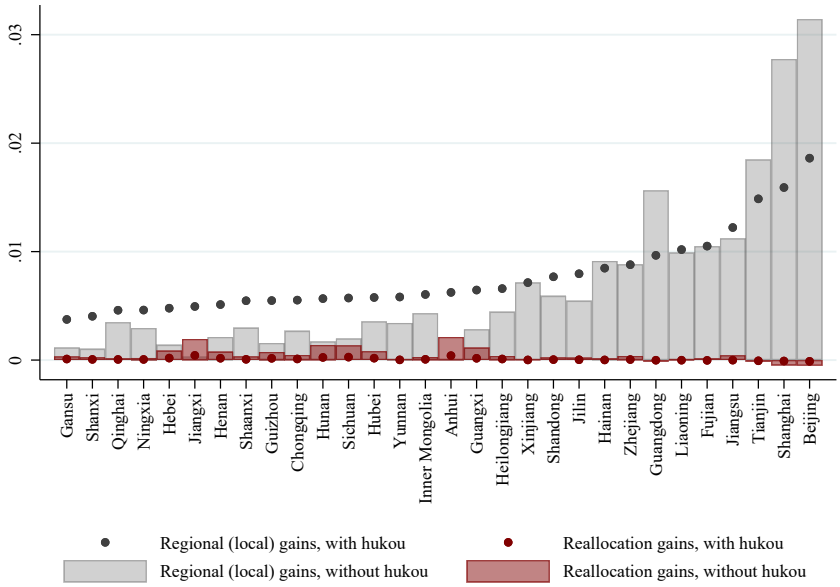


Figure 5: Comparing the Gains from Trade: Decomposing Channels

consumption feature Cobb-Douglas. As evident from Table 8, the aggregate predictions (columns (1)-(7)) experience almost no changes in the Cobb-Douglas case when the hukou frictions are reduced to zero. The distributional effects are summarized by the Theil index: a greater value indicates more uneven gains from trade. As shown in column (8), the Cobb-Douglas model predicts more evenly distributed gains from trade with the removal of hukou restrictions, although the magnitude is again very small.

Table 9 presents a battery of sensitivity checks on the baseline results. To keep the quantitative exercises tightly linked to my empirical analysis, I intentionally only introduced components that have direct correspondence in the empirical part to the model. However, modeling and calibration choices are still open to discussion. For example, migrant workers may pay different prices for public services, specific-factor profits are not necessarily distributed to all locals, and China's trade surplus actually grew significantly between 2000 and 2010, rather than remaining fixed. Finally, as discussed at the beginning of Section 5.1, the unit of analysis is not the same as those of the empirical regressions due to data limitations. In panel a of Table 9, I show that the main message of this section, namely eliminating the hukou system would lead to less gains from trade and amplify its negative distributional consequences, does not change when alternative modeling or calibration options are used. To facilitate the comparison, column (1) of panel a lists the baseline welfare results. In column (2), I introduce a public sector following Caliendo et al. (2021) and Fajgelbaum et al. (2015) and assume that migrant workers pay a higher price to access local public goods. In column (3), I assume that there is a mass of rentiers in each location and that they only consume local goods. In column (4), I match regional trade imbalances in the year 2010, which is a linear extrapolation based on data from 2002 and 2012 regional IO tables. In column (5), I calibrate the model at the

Table 8: Hukou Friction in Shaping the Impact of Trade: Model Comparison

	(1) Real Wage	(2) GDP	(3) Local Price	(4) Exports	(5) Imports	(6) GDPPC	(7) Welfare	(8) Theil index (Welfare)
Baseline								
With hukou	0.65%	0.64%	-1.40%	4.48%	6.37%	0.71%	0.72%	5.24%
Without hukou	0.47%	0.53%	-3.96%	-0.06%	3.97%	0.52%	0.59%	22.07%
Difference (%)	-28%	-17%	184%	-101%	-38%	-26%	-18%	322%
Cobb-Douglas								
With hukou	0.62%	0.60%	-1.62%	5.39%	5.99%	0.61%	0.62%	7.19%
Without hukou	0.62%	0.59%	-1.70%	5.17%	5.95%	0.61%	0.63%	6.07%
Difference (%)	0%	-2%	5%	-4%	-1%	0%	2%	-16%

Notes: The first two rows (except for column (8)) of each model present the aggregate changes of the variable of interest in response to Chinese tariff cuts before and after eliminating hukou frictions. The column (8) presents the Theil index of the welfare changes. The last row of each model presents the percent change in values, before and after eliminating hukou frictions. GDPPC represents GDP per capita.

prefecture level. The prefecture-level hukou measure is used to compute model implied migration frictions associated with the hukou system in this case, and the details of the additionally calibrated data are described in Appendix E.4. In all circumstances, the counterfactual welfare changes remain qualitatively the same, ensuring the validity of the baseline results. In particular, when calibrate the model at the prefecture-level, I find that the observed trade liberalization increases China's welfare by 0.78%, with the standard deviation being 0.32. If China abolishes the hukou system, the gains from tariff reductions would decrease to 0.60%, with the standard deviation increasing to 0.44%. These results are very similar to when I calibrate the model at the provincial level. The simulated regional employment changes also match qualitatively well with the observed data in this case, which I report in Figure A8, Appendix E.5.

Another major concern is that the quantitative results may be entirely driven by the specific values of a few parameters on the elasticity of substitution, which I simply taken from the existing papers. Panel b of Table 9 addresses this concern. As shown in Table 9-b, under a fairly wide range of values of elasticity values, the gains from trade in the presence of hukou frictions vary around 0.72%.[43], and eliminating the hukou frictions reduces the gains from trade and amplifies the negative distributional consequences in all cases. Overall, the sensitivity analyses confirm the robustness of the quantitative results.

6 Conclusion

This paper shows that trade liberalization can lead to significant spatial labor adjustments within a country, and internal migration frictions play an important role in shaping the impact of trade. I first use a rich dataset on Chinese regional economies and a novel measure of hukou frictions

[43]The aggregate gains are always equal to 0.72 is due to rounding. If I take a few more decimals, the number varies from 0.7151% to 0.7227%.

Table 9: Alternative Model Assumptions and Parameter Values

Panel (a)

	(1) Baseline	(2) Hukou-benefits	(3) Local Rentiers	(4) Trade Imbalances	(5) Prefecture Analysis
Gains from Trade, with Hukou					
Weighted Average	0.72%	0.72%	0.67%	0.65%	0.78%
Standard Deviation	0.26%	0.26%	0.29%	0.29%	0.32%
Gains from Trade, without Hukou					
Weighted Average	0.59%	0.55%	0.38%	0.53%	0.60%
Standard Deviation	0.52%	0.60%	0.35%	0.54%	0.44%

Panel (b)

	(1) $\kappa = 2.5$	(2) $\kappa = 3.5$	(3) $\theta_0 = 0.7$	(4) $\theta_0 = 0.98$	(5) $\theta_1 = 0.3$	(6) $\theta_1 = 0.7$	(7) $\theta_2 = 0.3$	(8) $\theta_2 = 0.7$	(9) $\theta_3 = 0.1$	(10) $\theta_3 = 0.5$
Gains from Trade, with Hukou										
Weighted Average	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%
Standard Deviation	0.27%	0.25%	0.26%	0.26%	0.27%	0.25%	0.26%	0.26%	0.26%	0.26%
Gains from Trade, without Hukou										
Weighted Average	0.64%	0.55%	0.59%	0.59%	0.56%	0.62%	0.41%	0.64%	0.59%	0.59%
Standard Deviation	0.46%	0.53%	0.52%	0.52%	0.63%	0.42%	0.51%	0.48%	0.52%	0.52%

Notes: Panel (a) presents the welfare effect of trade liberalization with and without hukou frictions with different model extensions. Column (1) presents the baseline results for comparison. In column (2), I introduce a public sector following Caliendo et al. (2021) and Fajgelbaum et al. (2015) and assume that migrant workers pay a higher price to access local public goods. In column (3), assume that there is a mass one of rentiers in each location and that rentiers consume local goods. In column (4), I instead match regional trade imbalances in the year 2010, which I extrapolate from 2002 and 2012 regional IO tables. Column (5) reports the quantification performed at the prefecture level rather than at the provincial level. Panel (b) presents the welfare change using the same model and counterfactual exercises as the benchmark analysis but varies one calibrated elasticity parameter at a time.

to document empirical patterns that suggest input-liberalization-induced labor reallocation across prefectures and the presence of hukou frictions. Then, guided by the empirical findings, I set up a quantitative spatial model with input-output linkages and hukou migration frictions to estimate the welfare impact of trade liberalization and the importance of the hukou system. Given the model, I quantify the cost of the hukou system and disentangle it from other migration costs. I find that tariff reductions improve China's aggregate welfare by 0.72% but magnify regional disparities. Abolishing the hukou system leads to a sizable improvement in aggregate welfare and has a strong redistributional impact. However, it decreases the gains from trade and amplifies trade's negative distributional consequences. My results shed light on the importance of accounting for migration frictions when evaluating both the aggregate and distributional consequences of trade reforms.

This paper contributes to a growing body of literature that examines the role of domestic frictions in shaping the impact of trade liberalization, as well as the literature on trade and local labor markets. While my focus is on China, according to the 2013 World Population Policies (United Nations, 2013), 60 percent of governments worldwide desired a major change in their country's spatial labor distribution, 80 percent of which had policies to influence internal migration. This paper's exercises could also inform migration policy and motivate research on other countries, possibly accounting for the interaction between migration frictions and other household characteristics.

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Online Appendix for: "Trade Liberalization and the Great Labor Reallocation" (Not for Publication)

A Data Appendix

The data appendix provides detailed information (supplementary to Section 2) on the data and measures used in the empirical exercises of this paper (both Section 2 and the Appendix.

A.1 Local Labor Markets

I choose *prefecture-level divisions* as my measure of local labor markets. A prefecture-level division is an administrative division ranking below a *province* and above a *county* in China's administrative structure. The majority of regional policies, including the overall planning of public transportation, are conducted at the prefecture level (Xue and Zhang, 2001). I therefore expect counties within the same prefecture-level city to have stronger commuting ties and better economic integration.[44]

The number of prefecture-level divisions is relatively stable over time, [45] Although some divisions did experience significant changes in their administrative boundaries, I use information on administrative division changes published by the Ministry of Civil Affairs of China to create time-consistent county groups based on prefecture boundaries from the year 2000. Prefecture-level employment is then defined as the total employment of a county group. If between 2000 and 2010 a county was split between several counties that belonged to different prefectures in 2010, I aggregate and assign those counties to the same prefecture. This results in 337 geographic units that I refer to as prefectures or regions, including four directly controlled municipalities and 333 prefecture-level divisions that cover all of mainland China.

A.2 Industries

I work with 71 industries classified based on the two-digit Chinese Standard Industrial Classification for 1994 (CSIC1994). This classification includes 5 agricultural industries, 5 mining and quarrying industries, 29 manufacturing industries, 3 energy supply industries, 37 service industries, a wholesale and retail trade industry, and a construction industry. I select the number of industries to achieve the maximum level of disaggregation at which I can collect Chinese production, employment and trade data. I report the industry list as well as the crosswalks from it to the two-digit CSIC1994, the Chinese 2002 IO industry classification, and the four-digit ISIC Rev.3 (International Standard Industrial Classification of All Economic Activities, Rev.3) in Table A1. Further details on industry

[44] I treat each directly controlled municipality (*Zhixiashi*) as a local labor market (the four directly controlled municipalities, Beijing, Tianjin, Shanghai, and Chongqing, are provincial-level administrative divisions). In addition, I combine directly controlled county-level divisions (*Shen Zhixia Xingzheng Danwei*) with the prefectures they belonged to before becoming independent administrative units. Directly controlled county-level divisions are counties that are directly administrated by the provincial government. Four provinces had directly controlled county-level divisions in 2000: Henan (Jiyuan), Hubei (Xiantao, Qianjiang, Tianmen, and Shennongjia), Hainan (17 county-level divisions, for example, Zhanzhou, Qiongshan, and Wenchang) and Xinjiang (Shihezi). By 2012, Zhanzhou had been established as a prefecture-level city, while Qianghai had become part of Haikou city, and Xinjiang province had established three more new directly controlled counties. My empirical results are robust to the exclusion of those counties.

[45] The number of prefectures is 336, 333, and 334 for the years 1990, 2000, and 2010, respectively.

construction can be found in the description of the data on *cost shares*.

A.3 Population Census

Many variables used in this paper are constructed using various publications of the Chinese Population Census from 1990, 2000, and 2010. The long form of the census, which covers 10% of the total population of China, asks respondents detailed information about their current address, employment status, hukou, and affiliation (among others). Data on current address and affiliation are then coded at the county- and three-digit industry level, respectively. The complete data are unfortunately not publicly available. Instead, the National Bureau of Statistics of China (NBS) publishes several datasets after each round of the census. These are the Tabulation of Population Census of China (National Tabulation), the Tabulation of Population Census of China by County (Tabulation of Population Census by County, which begins in 2000) and the Tabulation of Population Census released by each province. Each tabulation has a different focus. The National Tabulation provides most information at the aggregate level. The county tabulation has more disaggregated geographic information but aggregated information in other categories. The degree of aggregation of the provincial tabulations varies across provinces and years; this tabulation also has more missing data and discrepancies than the other tabulations. Unless noted otherwise, tabulations are obtained from the China Statistical Yearbooks Database (CSYD). In addition to the tabulations mentioned above, I also used the 1%, 1%, 0.095%, and 0.1% micro samples of the complete census data for the years 1982, 1990, 2000, and 2010, respectively, and the 10% of the year 2005 1% population survey (mini census). These samples are all long-form data. I obtain the data from the Integrated Public Use Microdata Series (IPUMS) for the years 1982 and 1990. The microdata samples allow richer interactions between variables, as they are identified at the individual level. However, they do not report individuals' county of residence for the years 2000 and 2005, making it impossible to calculate time-consistent prefecture employment. Another limitation of the data is their limited sample size, especially for 2000. I therefore choose to collect aggregate variables from census tabulations when possible, rather than inferring them from the micro sample.

A.4 Employment

To compute *prefecture employment*, I first collect employment information by county. I take data for the years 2000 and 2010 from the Tabulation of Population Census by County. For 1990, county-level employment is reported in the tabulation published by provinces. The tabulations of 21 provinces (out of 30)[46] and part of Hainan are available in CSYD. For the remaining provinces, I collect and digitize the employment data based on paper-based publications of the 1990 tabulations. These are available at Peking University's Institute of Sociology and Anthropology Library.

[46]Chongqing was part of Sichuan province in 1990.

Table A1: Industry Aggregation and Concordance

Aggregated Industry	Industry Name	CSIC1994 two-digit	NBS IO2002	ISIC Rev.3
1	Farming	1	1001	111,112,113,130
2	Forestry	2,12	2002,2003	200
3	Animal Husbandry	3	3004	121,122,150,8520
4	Fishery	4	4005	500
5	Agricultural Services	5	5006	140
6	Coal Mining and Dressing	6	6007	1010,1020,1030
7	Extraction of petroleum and Natural Gas	7	7008	1110,1120
8	Mining and Dressing of Ferrous Metals	8	8009	1310
9	Mining and Dressing of Nonferrous Metals	9	9010	1200,1320
10	Mining and Dressing of Other Minerals	10,11	10011,10012	1410,1421,1422,1429
13	Food Processing	13	13013,13014,13015,13016,13017,13018	1511,1512,1513
14	Food Production	14	13019	1514-1549
15	Beverages	15	15020,15021	1551,1552,1553,1554
16	Tobacco	16	16022	1600
17	Textiles	17	17023,17024,17025,17026,17027	1711,1712,1721,1722,1723,1729,1730
18	Garments and Other Fiber Products	18	18028	1810,1920
19	Leather, Furs, Down and Related Products	19	19029	1820,1911,1912
20	Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	20	20030	2010,2021,2022,2023,2029
21	Furniture Manufacturing	21	21031	3610
22	Papermaking and Paper Products	22	22032	2101,2102,2109
23	Printing and Record Medium Reproduction	23	23033	2211,2212,2213,2219,2221,2222,2230
24	Cultural, Educational and Sports Goods	24	24034,24035	3692,3693,3694
25	Petroleum Processing and Coking	25	25036,25037,37068	2310,2320,2330
26	Raw Chemical Materials and Chemical Products	26	26038,26039,26040,26041,26042,26043,26044	2411,2412,2413,2421,2422,2424,2429
27	Medical and Pharmaceutical Products	27	27045	2423
28	Chemical Fiber	28	28046	2430
29	Rubber Products	29	29047	2511,2519
30	Plastic Products	30	30048	2520
31	Nonmetal Mineral Products	31	31049,31050,31051,31052,31053	2610,2691,2692,2693,2694,2695,2696,2699
32	Smelting and Pressing of Ferrous Metals	32	32054,32055,32056,32057	2710
33	Smelting and Pressing of Nonferrous Metals	33	33058,33059	2720,2732
34	Metal Products	34	34060	2811,2812,2813,2892,2893,2899
35	Ordinary Machinery	35	35061,35062,35063	2731,2891,2911,2912,2913,2914,2915,2919
36	Equipment for Special Purposes	36,39	36064,36065	2921-2929,3311
37	Transport Equipment	37	37066,37067,37069,37071	3410-3599,5020
40	Electrical Equipment and Machinery	40	39072,39073,39074	3110,3120,3130,3140,3150,3190
41	Electronic and Telecommunications Equipment	41	40075,40076,40077,40078,40079,40080	3210,3220,3230
42	Instruments, Meters, Cultural and Office Machinery	42	41081,41082	3000,3312,3313,3320,3330
43	Other Manufacturing	43	42083,42084,43085	2930,3691,3699,3710,3720
44	Production and Supply of Electric Power, Steam and Hot Water	44	44086	4010,4030
45	Production and Supply of Gas	45	45087	4020
46	Production and Supply of Tap Water	46	46088	4100
47	Construction	47,48,49	47089	4510,4520,4530,4540,4550
52	Railway Transport	52	51090,51091	6010
53	Other Transport	53,57,58	52092	6023,6301,6303
54	Pipeline Transport	54	56097	6030
55	Waterway Transport	55	54094	6110,6120
56	Air Transport	56	55095,55096	6210,6220
59	Storage	59	58098	6302
60	Postal and Telecommunications Services	60	59099	6411,6412
61	Wholesale and Retail Trade	61,62,63,64,65	63102	5010,5030-5259
67	Catering Trade	67	67104	5520
68	Finance	68	68105	6511,6519,6591,6592,6599,6711,6712,6719
70	Insurance	70	70106	6601,6602,6603,6720
72	Real Estate	72,73,74	72107	7010,7020
75	Public Services	51,75	53093,79114,80115	6021,6022,9000,9233
76	Residential Services	76	82116	5260,7494,9301,9302,9303,9309,9500
78	Hotels	78	66103	5510
79	Leasing Services	79	73108	7111,7112,7113,7121,7122,7123,7129,7130
80	Commercial services	80,84	74109,74110	6304,6309,7411-7414,7430-7493,7495,7499
81	Recreational Services	81	92122	9249
82	Information and Consultative Services	82	60100	6420
83	Computer Application Services	83	61101	7210,7220,7230,7240,7250,7290
85	Health Care	85	85118	8511,8512,8519
86	Sports	86	91121	9241
87	Social Welfare and Social Security	87	86119	8531,8532
89	Education	89	84117	8010,8021,8022,8030,8090
90	Culture and Arts	90,91	88120	9211,9212,9213,9214,9219,9220,9231,9232
92	Scientific Research	92	75111	7310,7320
93	Polytechnic Services	50,93	76112,78113	7421,7422
94	Others	94,95,96,97,99	93123	7511-7530,9111-9199,9900

Industrial employment by county in 2000 is collected from the Tabulation of Population Census published by each province. The data are reported in 92 two-digit CSIC1994 divisions. The original data were collected from China Data Online; they are also available in the CSYD.[47] For both sets of data, I compared the values with those recorded in other tabulations (when available) at various aggregations and correct mis-recorded values. When aggregating to different levels, I also ensure that the data match the aggregated data reported in the tabulations.[48] I then sum the employment by county group to obtain the prefecture data. NBS reports 1990 employment after sample adjustment (except for Jilin province) but not for the years 2000 or 2010. The long form of the census is said to be randomly sampled to cover 10% of the total population. In reality, however, sampling rates vary across regions. To avoid potential bias, I exploit the fact that the population above the age of 15 is reported both in the full sample and in the long form. I proceed as follows: first, I collect data by county and then calculate the sum to obtain the population of the prefecture above age 15, from both the full sample and the long form. I then use the ratio between the two figures to proxy for the sampling rates of each prefecture. The rates vary substantially across prefectures, from 7.52% to 13.52% for 2000 and 7.29% to 11.50% for 2010. I finally divide the reported employment by the constructed sampling rates to obtain the prefecture employment for the years 2000 and 2010. Unfortunately, I do not find similar data to construct sampling rates for 1990. I therefore simply divide the 1990 employment of Jilin province by 10%. By doing so, I complete the final step necessary for obtaining the employment data used in my empirical analysis.

A.5 Population Measures

The data on prefecture *working-age population, total population, hukou population, and the number of migrants from other provinces in the past five years* are obtained from the Tabulation of Population Census by County. The original data are county-specific. I clean, adjust and aggregate those variables to the prefecture level following the same procedure as used for the employment data.

A.6 Cost Shares

China became a member of the WTO on 11 December 2001. I therefore use the IO table for the nearest year, 2002, to identify the cost shares of Chinese industries. That is, I implicitly assume that

[47] Unfortunately, I cannot construct a panel of employment by prefecture and sector. Both the national- and county-level tabulations report employment in aggregated industries (one-digit Chinese Standard Industrial Classification; 20 sectors). Most of the employment data published by provincial administrators are by disaggregated industry (two-digit) but with inconsistencies. In 2010, Shandong only reported employment by two-digit industry by province, Chongqing reported employment by one-digit industry, and Hainan was missing data for some industries; in 1990, Liaoning reported employment by one-digit industry, and Sichuan, Shanxi, and Hunan provinces had missing data for some industries and counties.

[48] When there are mis-recorded values, I cross-check the number from the provincial tabulation (when available), which also provides county-level employment for most provinces and most years; if this is not possible, I adjust the county's employment to be the prefecture employment minus the sum of employment of other counties in that prefecture.

industry cost structures adjust slowly to trade liberalization. The 2002 IO industries are classified in a system close to the two-digit CSIC1994, with a slightly different aggregation. For instance, some mining and manufacturing IO divisions correspond to three-digit CSIC industries, while the "Wholesale" division corresponds to several two-digit CSIC classifications. I therefore construct a common industry code between IO2002 and CSIC1994 by slightly aggregating both classifications. Ultimately, I map 122 IO and 92 CSIC divisions to 71 more aggregated industries. I then aggregate the IO table to 71 industries and compute the cost shares.

A.7 Tariffs

I use the simple average MFN applied tariffs at the HS6 product level from the UN's TRAINS database to calculate tariff changes. To concord tariffs from HS6 to my constructed industry classification, I first construct a many-to-one crosswalk from ISIC Rev.3 to the constructed classification and then use the crosswalk from HS6 to ISIC Rev.3 published by the World Integrated Trade Solution (WITS) to link HS6 to the classification. The final crosswalk concords HS6 products to 43 aggregated industries, spanning from agriculture to residential services. In the last step, I apply the crosswalk to the tariff data and then take the simple average to obtain the aggregated industry tariffs used in the empirical analysis.

Input tariffs cuts are calculated as the input-cost-weighted average of tariff reductions. To construct *external tariff reductions*, I first compute the prefecture-export-weighted average of tariff reductions that China faced from its trading partners over the 2000-2005 period for each industry and each prefecture. I then take the δ_{is}-weighted average of this variable to obtain the final prefecture measure of external tariff reductions. Exports by industry, prefecture, and destination market are obtained by aggregating firm-level exports from the 2000 Chinese customs data. The Chinese customs trade data cover the universe of all Chinese import and export transactions by month; they contain the values (in US dollars) of imports and exports at the 8-digit HS classification (approximately 7,000 product categories). The data are at the transaction level and contain firm information such as ownership (domestic, private, foreign, and state-owned), trade regime (processing versus non-processing), and firm location. These allow me to construct bilateral trade flows between Chinese prefectures and other countries. I exclude intermediary trade following Fan (2019) when calculating export shares; the empirical results are also robust to the exclusion of processing exports or exports by state-owned enterprises.

A.8 Other Variables

To construct *real exchange rate change by prefecture*, I first compute industry-specific real exchange rates as trade-weighted averages of real exchange rates between China and its trading partners. To obtain the real exchange rate, I first collect countries' nominal exchange rates with respect to the US dollar from Penn World Table 8.1 and compute the nominal exchange rate between China and

Table A2: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Regional input tariff cuts, 2000-2005	0.03	0.01	0	0.12	337
Regional output tariff cuts, 2000-2005	0.12	0.02	0	0.20	337
Destination tariff cuts, 2000-2010	0.01	0.03	-0.11	0.23	337
Employment changes, 2000-2010	0.07	0.14	-0.36	0.66	337
Employment in 2000	14.24	0.91	10.55	16.73	337
Population changes, 2000-2010	0.07	0.12	-0.25	0.64	337
Population in 2000	14.89	0.86	11.47	17.18	337
Working age population changes, 2000-2010	0.13	0.13	-0.26	0.64	337
Working age population in 2000	14.45	0.89	10.76	16.88	337
Hukou population changes, 2000-2010	0.48	0.13	0.07	1.25	337
Hukou population in 2000	16.77	0.91	13.27	19.29	337
Changes in migration inflows, 2000-2005 versus 2005-2010	0.95	0.49	-2.22	2.38	337
Total migration inflows, 2000-2005	12.42	1.30	9.97	16.99	337
Employment changes, 1990-2000	0.11	0.18	-0.27	1.54	337
Employment in 1990	14.12	0.95	10.34	16.75	337
SOEs employment, 2000	10.80	1.20	5.35	13.76	332
SOEs employment share changes, 2000-2009	-1.09	0.76	-6.22	0.81	337
Prefecture-level exchange rates exposure, 2000-2010	0.01	0.02	-0.05	0.13	337
Share of employment in construction industry, 2000	0.03	0.02	0.001	0.09	337
Share of employment in real estate industry, 2000	0.00	0.00	0	0.03	337
Prefecture-level GDP per capita, 2000	6.46	0.72	4.20	9.50	285
Provincial hukou measure	0.53	0.28	0	1	31
Provincial hukou measure (not normalized)	0.19	0.09	0.03	0.34	31
For hukou estimation					
Hukou granting dummy (obtained local hukou=1)	0.29	0.45	0	1	62260
Provincial GDP per capita, 1995	8.65	0.49	7.53	9.79	31
Rural-urban dummy (rural=1)	0.66	0.47	0	1	62260
Gender dummy (male=1)	0.5	0.5	0	1	62260
Marriage dummy (married=1)	0.58	0.50	0	1	62260
Ethnicity dummy (Han=1)	0.93	0.25	0	1	62260
Migration time	3.62	1.37	0	5	62260
Education (9 categories)	4.45	1.57	0	9	60010
$ln(age)$	3.15	0.57	0	4.55	61905

Notes: This table provides the descriptive statistics for variables used in the empirical analysis and for the construction of the hukou measure. All level variables are in logs, except birth rates, death rates, migration time, age (age and age squared), dummy variables and the categorical variable education.

other countries and then deflate the data using CPI indices from the World Bank. I then take the change in the logged real exchange rate from 2000 to 2010 for each industry and calculate regional exchange rate shocks as δ_{is}-weighted averages.

Employment at state-owned Enterprises (SOEs) is calculated as the total employment of *industrial* SOEs in each prefecture. I collect the data from the NBS Annual Surveys of Industrial Firms, which provides extensive firm-level information, including their ownership and location. The NBS survey is particularly well suited for my analysis because all state-owned industrial firms are covered in the survey. I sum SOE employment by county for the years 2000 and 2009. I choose not to

use data from 2010 because they contain erroneous information on employment statistics (Brandt et al., 2014). To aggregate the county-level SOE employment to the prefecture level, I construct a crosswalk from 2009 county to the time-consistent prefectures. One potential limitation is that the survey covers industrial firms only (mining and quarrying, manufacturing, production and supply of electric power, gas and water). However, this is less of a concern for my study, as the majority of SOE layoffs occurred in the manufacturing and mining industries such as textiles, weapons and ammunition, and coal mining and dressing (Li et al., 2001).

The *regional employment shares of the construction* and *real estate industries* are computed using employment data by prefecture and industry from the year 2000; *pre-decade employment trend* is computed as the difference in logged employment between 2000 and 1990, using the prefecture employment panel I constructed. The *great-circle distance* between provincial capitals is constructed using the 2010 China Administrative Regions GIS Data from ChinaMap. Finally, I calculate *GDP per capita* by prefecture by dividing the prefecture GDP by total population; both sets of data come from the city statistics of China Data Online.[49]

B Details of the Trade Reform and the Chinese Hukou System

B.1 China's Trade Liberalization, 1980-2010

China's average tariff rate was as high as 56% before to the economic reforms of the early 1980s. This tariff schedule was enacted in 1950 and remained essentially constant over the subsequent decades, in part due to the relative irrelevance of trade policy in a centrally planned economy. In a planned economy, import and export levels are determined by the government rather than market supply and demand. During this time, 10 to 16 trading companies managed China's commerce (Ianchovichina and Martin, 2001). These corporations were in charge of a variety of import and export products, making them monopolies in terms of the range of products for which they were responsible (Lardy, 1991).

Beginning in 1982, China undertook a series of voluntary tariff reductions that brought the simple average tariff down to 24% in 1996 (Li, 2013). During the same time period, however, the government also introduced extensive and complex trade controls, including import quotas, licenses, and other non-tariff barriers (Blancher and Rumbaugh, 2004). In addition, the Chinese RMB depreciated by more than 60% in the 1980s and an additional 44% in 1994 in order to help firms export (Li, 2013). Finally, various preferential arrangements, such as import tariff exemptions or reductions for processing exports, military usage imports, special economic zones, and imports from specified border regions, have also resulted in large tariff redundancies. According to Ianchovichina and Martin (2001), only 40% of imports were subject to official tariffs during this period of time. Consequently, changes in tariff duties do not reflect the changes in the actual protection faced by

[49] 284 prefectures have the data available.

Chinese firms or the accessibility of imported inputs.

In 1996, to meet the preconditions for WTO accession, the Chinese government engaged in substantial reforms that did away with most of the restrictive non-tariff barriers. Trade licenses, special import arrangements, and discriminatory policies against foreign goods were reduced or eliminated to make tariffs the primary instruments of protection. The share of imports subject to licensing requirements fell from a peak of 46% in the late 1980s to less than 4% of all commodities by the time China entered the WTO. The state abolished import substitution lists and authorized tens of thousands of companies to engage in foreign trade transactions, undermining the monopoly powers of state trading companies. The transformation was similarly far-reaching on the export side (Lardy, 2005). The duty-free policy on imports for personal use in special economic zones was gradually abolished in the 1990s; the preferential duty in Tibet was abolished in 2001. Moreover, China also abolished, modified or added over a thousand national regulations and policies. At the regional level, more than three thousand administrative regulations, and over 188,000 policy measures implemented by provincial and municipal governments were stopped (Li, 2011).

Phased tariff reductions started in 2001. In 2000, China's simple average applied tariff was 17%, with the standard deviation across the six-digit Harmonized System (HS6) products being 12%. By the end of 2005, the average tariff level was reduced to 6%, and the standard deviation almost halved. The average tariff level stabilized after 2005.

In conclusion, China's trade had been subject to different protective measures prior to WTO accession, therefore the official tariff rates do not accurately reflect the true degree of liberalization in China. Therefore in this paper, I focus on China's trade liberalization after its WTO accession and measure changes in trade costs based on the change in tariff rates between 2000 and 2005.

To draw any causal implications of trade liberalization, the observed tariff changes must be unrelated to the counterfactual industry employment growth. Such a correlation may arise if trade policymakers impose smaller tariff cuts to protect weaker industries or if larger industries can lobby for smaller tariff cuts (Grossman and Helpman, 1994). Following Goldberg and Pavcnik (2005), Figure A1 plots the pre-liberalization log tariff levels by industry against the change in log tariffs over the period 2000-2005. As shown in Figure A1 industries with higher tariffs in 2000 experienced larger tariff cuts after WTO accession, with the correlation being -0.84. This suggests that the primary goal of policymakers was to reduce tariff rates in general and smooth cross-industry variations, thus alleviating the endogeneity concerns.

B.2 The Chinese Hukou System, 1950-2010

China introduced its hukou system in the early 1950s to harmonize the old household registration systems across regions. However, under the centrally planned economy, economic resources were mostly devoted to urban areas, as the government hoped to extract China's agricultural economic surplus to fuel urban industrialization. This uneven allocation of resources led to a massive influx

Notes: This figure plots logged tariff changes over the 2000-2005 period against the log year-2000 tariff levels. The sectoral tariff is calculated based on the simple average of MFN applied tariff rates at the HS6 product level from the TRAINS database. Correlation: -0.84; regression coefficient: -0.43; standard error: 0.044; t: -9.60.

Figure A1: Tariff Changes and Pre-liberalization Tariff Levels

of migrants into the main cities, threatening the agricultural production in rural areas (Kinnan et al., 2018). As a result, the hukou system was soon used to restrict both inter-regional and rural-to-urban migration. In 1958, the Standing Committee of the National People's Congress formally consolidated and supplemented existing regulatory practices and regulations, and established them as the Household Registration Regulation. According to the regulation, people could only apply to relocate after receiving the local hukou from the registration authorities. From then on, China entered an era with strict migration controls, with the hukou being at the center of the migration control system.

Since the beginning of the 1960s, free migration had become extremely rare. Migrant workers required six passes to work in provinces other than their own; rural-to-urban migrants, in addition to the above restrictions, would have to first acquire an urban hukou, the annual quota of which was 0.15% to 0.2% of the non-agricultural population of each locale (Cheng, 2007). Under the central planning system, coupons for consumption goods, employment and other resources were allocated entirely based on local hukou; urban dwellers without local hukou would be fined, arrested and deported. These practices made it impossible for people to work and live outside their authorized domain (Cheng and Selden, 1994).

In the early 1980s, China latched onto a labor-intensive, export-oriented development strategy that created an increasingly large labor demand in cities. In 1984, the State Council allowed rural populations to reside in villages with self-sustained staples, and migration policy then began to relax over time. In 1984, the Ministry of Public Security of China allowed people to migrate freely conditional on applying for a temporary residential permit upon arrival. In 1993, China officially ended the food rationing system, and internal migration was thus no longer limited by hukou-based

consumption coupons. The distinction between rural and urban hukou also gradually became less important (Bosker et al., 2012) and the rural-to-urban migration quotas were officially abolished in 1997 (Chan, 2009). Nevertheless, the hukou system continues to serve as the primary instrument for regulating inter-regional migration. As cheap labor continues to flood the labor market, in the absence of related fiscal transfers, local governments in general have very little incentive to provide public services to migrant workers. Individuals who do not have a local hukou in the place where they live are not able to access certain jobs, schooling, subsidized housing, healthcare and other benefits enjoyed by those who do.

The stringency of the hukou system varies across regions. As part of a contemporaneous reform devolving fiscal and administrative powers to lower-level governments, local governments have largely gained the authority to determine the number of hukou to issue in their jurisdictions. In 1992, some provinces began to offer temporary resident permits for anyone who has a legitimate job or business in one of their major cities, and some grant hukou to high-skilled professionals or businessmen who make large investments in their region (Kinnan et al., 2018). The most significant change is the introduction of two particular types of residential registration, the so-called temporary residential permit and the blue-stamp hukou. Unlike the regular hukou, these are not administered by the central government; instead, their design and implementation are up to local governments. While the temporary resident permit can be issued to anyone who has a legitimate job or business in the city, citizens who want a blue-stamp hukou are usually required to pay a one-time entry fee called the urban infrastructural construction fee, which varies between a few thousand in small cities and 50,000 Chinese RMB in more "attractive" cities. Because local governments can decide to a large extent on their migration policy, the stringency of these policies and general hukou issuing rules differ significantly across regions. For instance, it is famously difficult to obtain a hukou in Beijing or Shanghai, while Henan is relatively generous in granting local hukou to migrants.

The above-mentioned practices led to a formal hukou reform launched by the central government in 1997. The major aspects of the reform included officially abolishing the rural-to-urban migration quotas and approving the selective migration policies. After an experimental period, the national implementation of the reform began in 2001. However, this reform, which is largely an affirmation of local policies that were already in practice, has generally been put on hold since mid-2002 following stability concerns (Wang, 2004). According to Chan and Buckingham (2008) and many others, it only had a marginal impact in facilitating internal migrations. Similar arguments are made in Hou (2014), Sun et al. (2011), Ran et al. (2011) and Zhang and Chen (2014). In particular, using an individual-level panel of the National Rural Social-economic Survey, Sun et al. (2011) finds little evidence that hukou reforms between 2003 and 2006 affected the migration of rural workers. Despite the general increase in the number of migrants over the last quarter century, the annual number of hukou migrants recorded by the Ministry of Public Security remained stable between 1992 and 2008 (Chan, 2013). In 2011, "a hukou reform" was again mentioned in China's Five-Year Plan, but

the exact plan only began to take shape in 2014.

C The Hukou Measure: Estimation, Comparison, and the Relevance Tests

In this subsection, I provide more details on the construction of the hukou measure used in this paper and the relevance tests. I also discuss and compare my measure with existing hukou policy indices developed using textual analysis of laws and regulations, specifically those of Wu et al. (2010), Kinnan et al. (2018), Fan (2019), and Tian (2021).

C.1 Estimation Results and Robustness

As discussed in Section 2.2, the estimation results of the baseline hukou regression are reported in column (1) of Table A3. The results are straightforward and have the expected signs. Married individuals with higher levels of education and longer periods of local residence have a greater probability of obtaining a hukou. Women are also more likely to obtain a hukou in the place of migration, possibly because women work and marry elsewhere more often in China compared to men. Individuals from ethnic minorities also have a greater chance of obtaining a local hukou, which may result from preferential treatment by the government for ethnic minorities. Importantly, if the region in which one moves into is more developed than the region from which one moves out, the greater the probability that the individual will obtain a local hukou. This controls for the demand for local hukou from migrants. The chance of obtaining a local hukou is also positively correlated with age, but as we would expect, this effect is not linear.

For prefectures with low migrant inflows, the fixed effects may not be estimated precisely. Therefore, in columns (2) and (3), I estimate regression results using provincial fixed effects and exclude prefectures with fewer than 30 migrants, respectively. In columns (4) and (5), I focus on migrants of rural origin and immigrants with ties to local households, respectively, to address the problem that the hukou granting probability may also reflect an individual's desire for a local hukou. These immigrants are more likely to want to permanently settle in their destination locations, so their demand for local hukou should be rigid. The point estimates do not change much, except when the estimation sample only includes migrants with local familial ties. The sample size is substantially smaller in this case, so some variables are not precisely estimated, and the estimated coefficient on $\Delta ln(GDPPC)_{d-o}$ becomes negative. One explanation is that the difference in individual development (such as human capital accumulation) between migrant-in and migrant-out regions is also reflected in $\Delta ln(GDPPC)_{d-o}$. The larger the gap, the less competitive the migrant is in unobserved abilities or skills, which may reduce her prospects of acquiring a local hukou in the destination place. By focusing on migrants with local family ties, I most likely chose a sample of individuals with perfectly inelastic demand, for which this effect prevails.

Table A3: Hukou Friction Measure: Estimation and Robustness

	Baseline	Province FE	Exclude $mig. < 30$	Rural Origin	Family Ties
	(1)	(2)	(3)	(4)	(5)
$\Delta ln(GDPPC)_{d-o}$	0.16***	0.12***	0.16***	0.21***	-0.30***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.11)
Rural	-0.32***	-0.33***	-0.32***	-0.44***	-0.25***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Female	0.05***	0.06***	0.05***	0.06***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Married	0.07***	0.09***	0.07***	0.09***	0.10***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Han Ethnic	-0.04***	-0.05***	-0.04***	-0.05***	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Migrated 1998	0.07***	0.08***	0.07***	0.06***	0.09***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Migrated 1997	0.11***	0.11***	0.11***	0.08***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Migrated 1996	0.14***	0.15***	0.14***	0.13***	0.17***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Migrated 1995	0.22***	0.23***	0.22***	0.20***	0.20***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Migration within province	0.11***	0.12***	0.11***	0.08***	0.11***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Primary education	-0.00	0.00	-0.01	-0.04	0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Lower secondary education	-0.00	-0.00	-0.00	-0.03	0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Upper secondary education	-0.01	-0.01	-0.01	-0.05*	0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Secondary vocational education	0.14***	0.14***	0.14***	0.11***	0.07
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Post-secondary non-tertiary education	0.18***	0.18***	0.18***	0.16***	0.12**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Bachelor	0.40***	0.40***	0.40***	0.34***	0.20***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Master and above	0.43***	0.43***	0.43***	0.17*	0.26***
	(0.04)	(0.04)	(0.04)	(0.09)	(0.06)
$ln(age)$	4.08***	4.27***	4.08***	2.92***	0.16
	(0.29)	(0.29)	(0.29)	(0.32)	(0.50)
$ln(age)^2$	-1.32***	-1.38***	-1.33***	-0.89***	-0.03
	(0.09)	(0.10)	(0.09)	(0.11)	(0.16)
$ln(age)^3$	0.14***	0.14***	0.14***	0.09***	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Observations	57,962	57,962	57,052	42,085	13,970
R-squared	0.48	0.45	0.48	0.53	0.23

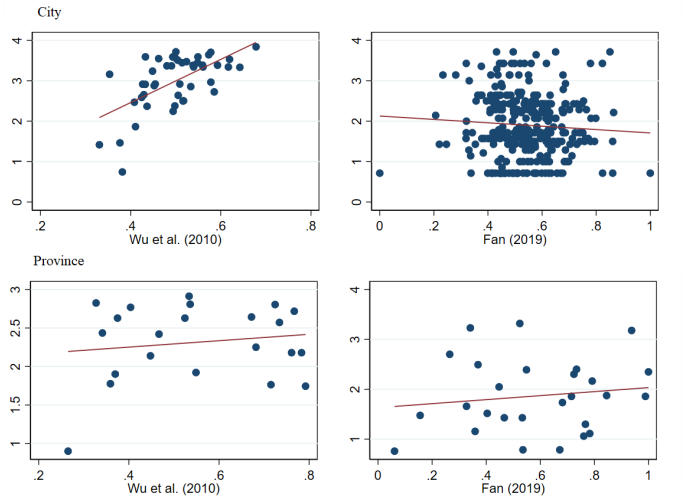
Notes: This table reports the regression results of constructing the Hukou measure and alternative measures used for robustness check. Column (1) corresponds to the regression result of the baseline hukou measure used throughout the paper; columns (2)-(5) corresponds to that of alternative hukou measures, which used either slightly different sample size or estimated with province-fixed effects. To avoid multicollinearity, the migration time "Migrated in 1999 or more recently" and the education category "Received no education" are removed. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

As demonstrated in Section 3.3, the empirical results in this paper are robust when using these different data samples, provincial fixed effects, or alternative aggregation methods to construct the hukou measures.

C.2 Legislative-based Measures: A Comparison

As said in Section C.2, several studies have attempted to develop hukou indices by textually analyzing local governments' laws and regulations. In particular, Wu et al. (2010) calculated the hukou

strictness around the year 2010 *in levels* for a handful major Chinese cities. Kinnan et al. (2018) created a hukou *reform* index for five provinces between 1992 and 2002. In a manner similar to Kinnan et al. (2018), Fan (2019) and Tian (2021) developed indices of hukou policy *changes*, but with an emphasis on the most recent years, at the prefecture level, and covers all Chinese regions.



Notes: This figure plots the hukou measure proposed in this paper against the hukou barrier index developed by Wu et al (2010) and the hukou reform index developed by Fan (2019). To facilitate the comparison, I translated the hukou barrier index in Wu et al (2010) using $X_i' = X_i - max(X_i)$, such that X_i', like my measure, is also an inverse measure of hukou frictions.

Figure A2: Comparing Hukou with Legislative-based Measures

Apart from the discussion in Section C.2, Figure A2 offers a visual comparison of different hukou indices. The main hukou measure employed in this study is compared with the hukou policy indices developed by Fan (2019) and Wu et al. (2010). The comparison at the provincial level is done by aggregating their city-level measures by simple averages. At the prefecture level, I compare their indices to my pre-average hukou measure. At both the provincial and prefecture levels, my hukou measure is highly positively correlated with Wu et al. (2010) (Spearman correlations are 0.65 and 0.54, respectively). Its correlation with Fan (2019) is positive at the provincial level, but at the prefecture level, it is close to zero. This is perhaps not surprising, since Wu et al. (2010)'s index measures the level of hukou frictions similar to mine, while that of Fan (2019) measures hukou friction changes. According to Fan (2019)'s index, for example, Beijing had one of the most frequent legislative changes between 2000 and 2010. But we would be mistaken if we conclude that Beijing has one of the most lenient hukou systems in China. Overall, the comparison presented in this subsection suggests that my measure is broadly consistent with the legislation-based measure when it is in levels and takes into account the details of the legislation, but the legislation-based measures may be sensitive to the way they are constructed.

C.3 The Hukou Measure and Migration Flows

This subsection provides relevance tests to show that the hukou measure proposed in this paper does account for differences in normalized migration shares and changes better than legislative-based measures used in the literature. Section 5.1 formally derives the following model-consistent relationship between bilateral migration and hukou frictions:

$$\ln(\frac{L_{hi}L_{ih}}{L_{hh}L_{ii}}) = 2\kappa\psi_0 + \kappa\psi_l \ln Hukou_i + \kappa\psi_l \ln Hukou_h + 2\kappa\psi_d \ln dist_{hi} + 2\kappa\psi_{cb}D_{c.b} + 2\kappa D_{r_h r_i} + \tilde{\epsilon}_{hi}. \quad \text{(A1)}$$

This specification is used to estimate migration costs associated with the hukou system in 5.1, but it also serves as a relevance test. By taking migration share in ratios, it ensures that all origin-specific and destination-specific factors, such as amenities, prices, and incomes, do confound the estimation results. Recall that the hukou measure is an inverse indicator of the migration frictions associated with the hukou system. Therefore, if the measure is relevant, I expect the point estimate of $\ln Hukou_i$ (hence also that of $\ln Hukou_h$) to be positive and significant.

Table A4: The Hukou Measure and Migration, 2000

	Main	Robustness		Legislative Measure	
	(1)	(2)	(3)	(4)	(5)
$\ln Hukou_i$	0.33***	0.32***	0.40***		0.40***
	(0.11)	(0.11)	(0.11)		(0.11)
$HukouLegal_i$				-0.65***	-0.65***
				(0.13)	(0.13)
Distance	-1.26***	-0.93***	-0.98***	-1.19***	-1.13***
	(0.20)	(0.23)	(0.23)	(0.23)	(0.22)
Common Border	2.20***	2.33***	2.35***	2.16***	2.18***
	(0.23)	(0.23)	(0.23)	(0.23)	(0.23)
Ethnic Distance		-0.80***	-0.78***	-0.84***	-0.81***
		(0.27)	(0.27)	(0.27)	(0.27)
Industry Distance			1.86*	0.25	2.48**
			(1.08)	(0.94)	(1.06)
Observations	930	930	930	930	930
R-squared	0.63	0.64	0.64	0.65	0.65

Notes: This table presents the regression results of equation (32) and robustness checks. Column (1) reports the baseline estimation used for constructing hukou frictions in Section 5.1. In columns (2) and (3), I further control for the bilateral distance in ethnic groups and industry mix. In columns (4) and (5), I examine the correlation between normalized migration flows and the hukou index constructed using legislative information. In all specifications, pair fixed effects among 8 economic regions are included. *** p<0.01, ** p<0.05, * p<0.1.

The regression results are reported in Table A4. Other things equal, regions with low migration frictions are indeed associated with higher normalized migrant shares. In the baseline case as presented in column (1), the point estimate of $\kappa\psi_l$ equals 0.33, which is positive and significant at the 1% level. In column (2), I further control for bilateral ethnic distance to account for migration frictions due to the regional difference in the ethnic mix. Following Conley and Topa (2002), I calculate the bilateral ethnic distance as the Euclidean distance between the vector of percentages of two ethnic groups (Han versus other) of two provinces. I use the 1% random sampled data of

the 3rd Population Census from 1982 to construct this measure to avoid simultaneity bias. If two regions have the same ethnic composition, this variable equals zero. In column (3), I also control for bilateral industry distance, which is calculated as the Euclidean distance between the vector of employment shares by industry. I find that the migrants tend to move to regions with ethnic groups similar to their home region, but with different industries. In both cases, the effects of hukou remain positive and significant. In column (4), I replace $\ln Hukou$ with a legislation-based measure by averaging the policy reform index developed by Fan (2019) over 1997-2000.[50] The estimate $\kappa\hat{\psi}_l$ turned negative (-0.65) and statistically significant at the 1% level, suggesting that regions with a smaller share of migrants tend to relax hukou policy more prior to 2000. This result again calls into question the relevance of the pre-2000 hukou reform index to the actual stringency of hukou across Chinese regions, since there were so few reforms.

Table A5: The Hukou Measure and Migration Changes, 2000-2010

	Main	Robustness		Δ Legislative Measure		
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln Hukou_i$	0.34***	0.34***	0.35***		0.33***	0.34***
	(0.04)	(0.04)	(0.05)		(0.05)	(0.05)
$\Delta HukouLegal_i$				0.13***	0.04	0.01
				(0.03)	(0.04)	(0.04)
$HukouLegal_i$						-0.21***
						(0.06)
Distance	0.27***	0.18*	0.17*	0.13	0.17*	0.12
	(0.08)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)
Common Border	0.76***	0.72***	0.73***	0.67***	0.71***	0.66***
	(0.09)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Ethnic Distance		0.22**	0.23**	0.26**	0.24**	0.22**
		(0.11)	(0.11)	(0.12)	(0.11)	(0.11)
Industry Distance			0.28	-1.31***	0.25	0.47
			(0.45)	(0.41)	(0.45)	(0.44)
Observations	930	930	930	930	930	930
R-squared	0.32	0.33	0.33	0.28	0.33	0.35

Notes: This table presents the regression results of a specification similar to equation (32), but replace normalized migration shares by its changes between 2010 and 2000, i.e. $\ln(\frac{L_{hh}L_{ii}}{L_{hi}L_{ih}})_{2010} - \ln(\frac{L_{hh}L_{ii}}{L_{hi}L_{ih}})_{2000}$. Column (1) reports the baseline estimation used for constructing hukou frictions in Section 5.1. In columns (2) and (3), I further control for the bilateral distance in ethnic groups and industry mix. In columns (4) to (6), In columns (4) and (5), I examine the correlation between normalized migration flows and the hukou index constructed using legislative information. For hukou legislation changes, I consider both its changes between 2010 and 2000 as well as its pre-2000 value. In all specifications, pair fixed effects among 8 economic regions are included. *** p<0.01, ** p<0.05, * p<0.1.

In Table A5, I run a similar regression to Table A4, but look at the change in normalized migration shares between 2000 and 2010 instead. Reassuringly, as columns (1) to (3) show, I do not find significant changes in migration patterns: all else equal, regions with lower hukou frictions according to my measure also experienced greater increases in normalized migration shares. The

[50] Fan (2019)'s hukou index starts from 1997. In Fan (2019), the hukou index was averaged over 1997-2000 and 2001-2005, and the difference between the two averaged numbers is used as the proxy for hukou policy changes between 2000-2005. Therefore, the most comparable measure to mine, i.e., hukou friction levels in 2000, is the average hukou index of Fan (2019)'s over 1997-2000.

point estimates for $\kappa\psi_l$ are positive, significant at the 1% level, and similar in magnitude to the level estimates. In column (4), I replace $\ln Hukou$ with the changes in hukou legislation. Specifically, I average Fan (2019)'s index for 2001-2010 and 1997-2000 and use its difference to represent the change in hukou policy from 2000-2010. As expected, the increase in migration is positively correlated with reforms liberalizing the hukou system (column (4)), but the estimate loses its economic and statistical significance when the hukou measure developed in this paper is also included (column (5)). This suggests that, even after policy reforms, hukou frictions across regions still are highly correlated with their initial levels. In column (6), I further control for hukou friction levels in 2000 as indicated by the legislative measure. The results change little: the point estimate of the hukou indicator developed in this paper remains significant and do not change significantly in magnitude.

Overall, the results reported in this subsection imply that the hukou measure developed in this paper is a more appropriate choice to reflect regional differences in the stringency of the hukou system, at least in a context similar to this study.

D Additional Empirical Results

Table A6: Effect of Input Tariff Cuts on Local Employment: Robustness I

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regional input tariff cuts (ΔRIT)	5.10***	4.40**	5.14***	3.18**	3.44**	4.45**	5.07***
	(1.65)	(1.89)	(1.64)	(1.39)	(1.48)	(1.63)	(1.67)
Pre-liberalization employment trend		0.06					
		(0.09)					
Changes in state-owned employment shares			-0.01				
			(0.01)				
Real exchange rate				1.26**			
				(0.57)			
Initial share of employment, real estate					10.60***		
					(3.18)		
Capital dummy						0.10***	
						(0.02)	
Drop special economic zones							Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337	337	330
R-squared	0.66	0.67	0.66	0.67	0.69	0.69	0.66

Notes: The dependent variable is the 10-year change in logged prefecture employment. The sample contains 333 prefectures and four directly controlled municipalities. All regressions include the full vector of control variables from column (3) of Table 1. Robust standard errors in parentheses are adjusted for 31 province clusters. Models are weighted by the log of the beginning-of-period prefecture employment. *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Effect of Input Tariff Cuts on Local Employment: Robustness II

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regional input tariff cuts (ΔRIT)	-1.18	-4.56*	-0.78	-3.33	-1.86	-0.89	-0.67
	(2.02)	(2.40)	(2.05)	(2.16)	(1.98)	(2.01)	(2.07)
Regional input tariff cuts × Hukou	18.45***	24.13***	17.66***	20.22***	15.84**	16.26**	14.90***
	(6.05)	(6.61)	(5.94)	(7.20)	(6.42)	(6.11)	(5.32)
Pre-liberalization employment trend		0.05					
		(0.15)					
Changes in state-owned employment shares			-0.04				
			(0.02)				
Real exchange rate				1.81			
				(1.43)			
Initial share of employment, real estate					5.00		
					(5.41)		
Capital dummy						0.05	
						(0.05)	
Drop special economic zones							Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337	337	330
R-squared	0.69	0.71	0.70	0.70	0.72	0.71	0.69

Notes: The dependent variable is the 10-year change in logged prefecture employment. The sample contains 333 prefectures and four directly controlled municipalities. All regressions include the full vector of control variables from column (7) of Table 1. When including each additional control, its interaction with the hukou measure is also included – none of the estimates are statistically significant and therefore are not reported. Robust standard errors in parentheses are adjusted for 31 province clusters. Models are weighted by the log of the beginning-of-period prefecture employment. *** p<0.01, ** p<0.05, * p<0.1.

Table A8: Effect of Input Tariff Cuts on Other Adjustment Margins Excluding Tibet and Northwest Provinces

	Total Population		Working Age population		Migrant Inflows		Hukou Population	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regional input tariff cuts	6.14***	1.36	5.03**	-2.57	19.70**	-6.53*	0.15	-4.70*
	(1.44)	(2.38)	(1.99)	(2.74)	(9.26)	(3.79)	(0.94)	(2.54)
Regional input tariff cuts × Hukou		13.52**		21.42***		80.42***		10.97**
		(5.39)		(6.54)		(14.97)		(4.31)
Regional output tariff change	-2.97***	-3.05	-2.37**	-2.56	-6.28	-0.24	-3.66***	-4.23
	(0.83)	(2.32)	(0.93)	(2.11)	(5.46)	(3.99)	(0.97)	(3.12)
Regional output tariff change × Hukou		1.96		3.15		-8.36		2.04
		(4.75)		(4.55)		(12.38)		(5.18)
External tariff change	0.24	0.90	0.44	0.83	2.72**	5.71	0.06	0.63
	(0.23)	(0.90)	(0.29)	(0.99)	(1.23)	(4.64)	(0.24)	(0.95)
External tariff change × Hukou		-1.36		-1.03		-6.62		-1.13
Pre-liberalization Y	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	280	280	280	280	280	280	280	280
R-squared	0.62	0.64	0.57	0.62	0.45	0.50	0.72	0.73

Notes: The dependent variables are the 10-year changes in the logged total population, working age population, migrant inflows from other provinces between 2005 and 2010 and between 1995 and 1990, and population holding local hukou permits (in columns (1)-(2), (3)-(4), (5)-(6) and (7)-(8), respectively). The sample contains 274 prefectures and four directly controlled municipalities. Prefectures in Tibet and Northwest China (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang) are excluded. All regressions include the full vector of control variables from column (3) of Table 1; regressions with the interaction terms further include the interaction between the hukou measure and other tariff changes as in column (7) of Table 1. Robust standard errors in parentheses are adjusted for 31 province clusters. The models are weighted by the log of the beginning-of-period prefecture population. *** p<0.01, ** p<0.05, * p<0.1.

Table A9: Control for Hukou Policy Changes (Full Table)

	Control $\Delta Hukou$	
	(1)	(2)
Regional input tariff cuts (ΔRIT)	5.19***	2.06
	(1.61)	(2.9)
Regional input tariff cuts × Hukou		16.27**
		(6.29)
$\Delta HukouLegal$	0.02*	0.08
	(0.01)	(0.08)
Regional input tariff cuts × $\Delta HukouLegal$		-0.98
		(0.6)
Regional output tariff change × $\Delta HukouLegal$		-0.47
		(0.42)
External tariff change × $\Delta HukouLegal$		-0.13
		(0.76)
Baseline controls	Yes	Yes
Province fixed effects	Yes	Yes
Observations	337	337
R-squared	0.67	0.70

Notes: Robust standard errors in parentheses are adjusted for province clusters. The models are weighted by the log of the beginning-of-period prefecture employment. *** p<0.01, ** p<0.05, * p<0.1.

Table A10: Hukou for University Students: Placebo

(a) Hukou-granting probability: university students vs. other types of migrants

	No. of Provinces	Mean	Std.Dev.	Min.	Max.
University students	28	0.97	0.03	0.92	1
Rural workers	31	0.30	0.14	0.02	0.49
Recent university graduates (age 22-27)	25	0.79	0.18	0.40	1.00
Total migrants	31	0.37	0.14	0.07	0.56

Notes: This subtable presents the summary statistics of the hukou-granting probability by migrant type. The hukou-granting probability for a given migrant type is calculated as the share of individuals who have obtained local hukou among migrants of that type. As before, I focus on individuals who moved to the prefecture-level city in which they live in the past 5 years. All variables are calculated using the 0.095% sample of the 2000 population census. In the sample, 18 to 22 year-olds accounted for over 90% of university students.

(b) Relevance tests and placebo hukou measure

	Relevance: Hukou Measure			Placebo: Local Employment
	(1)	(2)	(3)	(4)
University students	1.47			
	(1.83)			
Rural workers		1.66***		
		(0.18)		
Recent university graduates (age 22-27)			0.70**	
			(0.32)	
Regional input tariff cuts (ΔRIT)				9.21*
				(5.29)
Regional input tariff cuts × Hukou$_{Uni}$				-11.24
				(15.40)
Baseline controls				Yes
Province FEs				Yes
Observations	28	31	25	308
R-squared	0.03	0.64	0.22	0.66

Notes: Columns (1)-(3) present the correlation between the hukou measure and the hukou-granting probability by migrant type. Column (4) reports the placebo result of regressing regional input tariff cuts on the change in logged prefecture employment, using the hukou measure constructed based on migrant university students. Controls include province fixed effects and the full vector of control variables from column (7) of Table 1; robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A11: Changes in Migration Inflow by Individual Types

	Skill Type				Working Migrants		Placebo: Marriage Migrants			
	High-skilled		Low-skilled				Levels		Shares	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Regional input tariff cuts (ΔRIT)	32.26***	-6.71	20.53***	-1.93	27.25***	-6.42	7.69*	5.29	-39.97***	1.41
	(8.11)	(9.13)	(5.72)	(7.39)	(6.88)	(9.78)	(4.38)	(15.65)	(10.72)	(16.44)
Regional input tariff cuts × Hukou		97.80***		73.82***		108.67***		7.28		-113.41***
		(22.83)		(20.83)		(21.63)		(35.06)		(35.19)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	184	184	328	328	304	304	243	243	243	243
R-squared	0.40	0.44	0.46	0.47	0.39	0.41	0.51	0.52	0.37	0.41

Notes: Columns (1)-(8) present the impact of input tariff cuts on labor inflows by 4 individual (age 15-65, not in school) types: high-skilled workers, low-skilled workers, migrants who moved for working purpose, and migrants who moved for marriage reasons, respectively. Columns (9)-(10) present the impact of input tariff cuts on the share of marriage migrants in total migrants. All regressions include the full vector of control variables from column (3) of Table 1; models with the interaction terms further include the interaction between the hukou measure and other tariff changes as in column (7) of Table 1. All dependent variables are calculated using the 0.095% sample of the 2000 population census and 0.1% sample of the 2010 population census. Although the National Assembly reported positive labor inflows in all prefectures, I observe prefectures with zero inflows due to my limited micro-sample size. Those prefectures are dropped from the analysis. Robust standard errors are in parentheses. The models are weighted by the log of the beginning-of-period prefecture population. *** p<0.01, ** p<0.05, * p<0.1.

E Quantification Appendix

E.1 Gains from Trade and the Distributional Consequence under Cobb-Douglas

To gain intuition on why the Cobb-Douglas (CD) model tends to predict a small role of labor allocation in affecting the gains from trade, it is useful to write down the equilibrium in relative changes when both production and consumption feature CD:

$$\hat{c}_{is} = \hat{w}_i^{\alpha_{is}(L)} \hat{r}_i^{\alpha_{is}(S)} \prod_{k \in K} \hat{P}_{ik}^{\alpha_{is}(k)}; \tag{A2}$$

$$\hat{\lambda}_{jis} = \left(\frac{\hat{\tau}_{jis} \hat{c}_{js}}{\hat{P}_{is}} \right)^{-\theta_s}; \tag{A3}$$

$$\hat{P}_{is} = \left(\sum_{j \in N} \lambda_{jis} \left(\hat{\tau}_{jis} \hat{c}_{js} \right)^{-\theta_s} \right)^{-\frac{1}{\theta_s}}; \tag{A4}$$

$$R'_{is} = \sum_{j \in N} \lambda_{ijs} \hat{\lambda}_{ijs} (\beta_s Y'_j + \sum_{k \in K} \alpha_{jk}(s) R'_{jk}); \tag{A5}$$

$$Y'_i = w_i L_i \hat{w}_i \hat{L}_i + r_i S_i \hat{r}_i; \tag{A6}$$

$$\hat{\pi}_{hi} = \frac{\left(\hat{y}_i / \hat{P}_i \hat{d}_{hi} \right)^{\kappa}}{\sum_{n \in N} \pi_{hn} \left(\hat{y}_n / \hat{P}_n \hat{d}_{hn} \right)^{\kappa}}; \tag{A7}$$

$$\frac{\sum_{s \in K} L_{is} \hat{R}_{is}}{\hat{w}_i} = \sum_{h \in N} \hat{\pi}_{hi} L_{hi}; \tag{A8}$$

$$\hat{r}_i = \sum_{s \in K} \frac{\alpha_{is}(S) R_{is} \hat{R}_{is}}{\sum_{k \in K} \alpha_{ik}(S) R_{ik}}, \tag{A9}$$

where $\hat{y}_i = \frac{Y'_i}{Y_i \hat{L}_i}$, $\hat{P}_i = \prod_{s \in K} \hat{P}_{is}^{\beta_s}$, and $L_{hi} \equiv \pi_{hi} \bar{L}_h$.

Consider a model-based difference-in-difference counterfactual exercise: first calculate the effect of tariff cuts starting from the observed initial equilibrium (first scenario, denote as dE), and then calculate the effect of the same trade shock but starting from the equilibrium where the hukou restrictions are removed (second scenario, denote as dE'). By comparing these two changes (with the difference denoted by Δ), one can see the extent to which migration frictions affect the gains from trade. Since all share parameters are constant, the only difference between these two counterfactual scenarios is the different initial values of λ_{ijs}, w_i, L_{is}, r_i, R_{is} and π_{hi} that are used to compute the equilibrium changes. Since $\alpha_{is}(L)$, $\alpha_{is}(S)$, S_i and $\bar{L}_h$ are exogenous variables, once R_{is} and π_{hi} are known, w_i, r_i and L_{is} can be computed. Thus, essentially only the initial values of λ_{ijs}, R_{is} (or after a normalization, the per capita revenue R_{is}/L_i) and π_{hi} matter. Therefore, unless the reduction of

hukou frictions leads to very large changes in λ_{ijs}, R_{is}/L_i and π_{hi}, the difference in regional real income changes in the first and second scenarios will be small compared to the real income changes themselves.

Next, I consider the changes of aggregate welfare in response to trade shocks. Using the $\dot{x} \equiv dlog(x)$ notation, the log changes in welfare can be written as:

$$\dot{U}_h = \sum_{i \in N} \pi_{hi} (\frac{\dot{y}_i}{P_i}). \tag{A10}$$

Therefore, the difference regarding welfare changes for individuals holding hukou from h, between dE' and dE, is given by:

$$\begin{aligned} \Delta \dot{U}_h \equiv \dot{U}_h^{'} - \dot{U}_h &= \sum_{i \in N} \pi'_{hi} (\frac{\dot{y_i'}}{P_i'}) - \sum_{i \in N} \pi_{hi} (\frac{\dot{y}_i}{P_i}) \\ &= \sum_{i \in N} \Delta \pi_{hi} (\frac{\dot{y}_i}{P_i}) + \sum_{i \in N} \pi_{hi} \Delta (\frac{\dot{y}_i}{P_i}). \end{aligned} \tag{A11}$$

When $\Delta(\frac{\dot{y}_i}{P_i})$ is small compared to $\Delta \pi_{hi}$ and $(\frac{\dot{y}_i}{P_i})$, the changes in the gains from trade for individuals with h-location hukou, $\Delta \dot{U}_h$, is approximately equal to:

$$\Delta \dot{U}_h \approx \sum_{i \in N} \Delta \pi_{hi} (\frac{\dot{y}_i}{P_i}). \tag{A12}$$

The population-weighted average of welfare changes at the national level can be expressed as:

$$\dot{U} \equiv \sum_{h \in N} \frac{L_h}{L} \dot{U}_h = \sum_{h \in N} \frac{L_h}{L} \sum_{i \in N} \pi_{hi} (\frac{\dot{y}_i}{P_i}) = \sum_{i \in N} \frac{L_i}{L} (\frac{\dot{y}_i}{P_i}). \tag{A13}$$

Similarly, $\Delta \dot{U}$ is approximately equal to:

$$\Delta \dot{U} \approx \sum_{i \in N} \frac{\Delta L_i}{L} (\frac{\dot{y}_i}{P_i}) \tag{A14}$$

Note that:

$$\sum_{i \in N} \frac{\Delta L_i}{L} = \sum_{i \in N} \frac{L_i'}{L} - \sum_{i \in N} \frac{L_i}{L} = 0. \tag{A15}$$

Therefore, the sign of $\Delta \dot{U}$ is the same as $corr(\Delta L_i, (\frac{\dot{y}_i}{P_i}))$. If the regions positively affected by trade shocks tend to be regions with high hukou restrictions, i.e. $corr(\Delta L_i, (\frac{\dot{y}_i}{P_i})) > 0$, under the Cobb-Douglas assumptions the model is likely to predict that the removal of the hukou restrictions will increase the gains from trade. If $corr(\Delta L_i, (\frac{\dot{y}_i}{P_i})) < 0$, the model is likely to predict the opposite.

On whether the distributional effects of trade will be amplified or diminished when the hukou

restrictions are removed, I consider the standard deviation (SD) of the individual welfare changes:

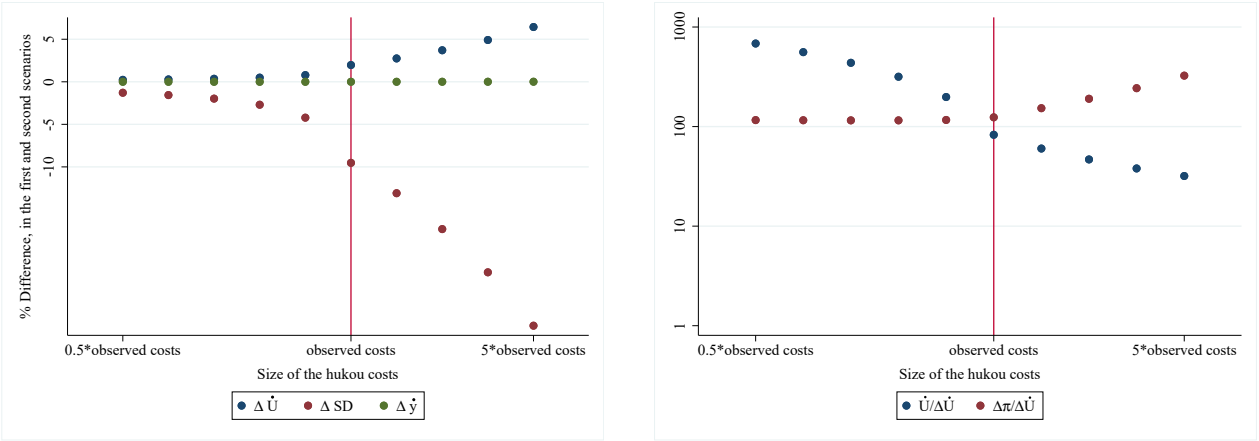
$$SD = \left[\sum_{h\in N} \frac{L_h}{L}(\dot{U}_h - \dot{U})^2\right]^{\frac{1}{2}} = \left[\sum_{h\in N} \frac{L_h}{L}(\dot{U}_h^2 - \dot{U}^2)\right]^{\frac{1}{2}}. \tag{A16}$$

Recall that:

$$\dot{U}_h = \sum_{i\in N} \pi_{hi}(\frac{\dot{y}_i}{P_i}), \tag{A17}$$

$$\dot{U} = \sum_{i\in N} \frac{L_i}{L}(\frac{\dot{y}_i}{P_i}). \tag{A18}$$

Since both L and L_h are exogenously given, when the regional real income does not change much in the first and second counterfactual scenarios, or more precisely when $\Delta(\frac{\dot{y}_i}{P_i})$ is small compared to $\Delta\pi_{hi}$, the variation of SD depends mainly on the extent to which π_{hi} differs from the overall labor distribution, $\frac{L_i}{L}$, in the initial equilibrium of the first and the second scenarios. The more restrictive the hukou system is, the larger the share of individuals holding hukou from a certain region h that remain in their region, and therefore the greater the difference between the spatial distribution of labor of a given region (in terms of hukou) and the spatial distribution of labor nationwide. When the hukou system is relaxed, π_{hi} adjusts in the opposite direction and depends less on h, becoming more similar to $\frac{L_i}{L}$. Therefore, under the Cobb-Douglas assumptions, the model is most likely to predict that the removal of the hukou restrictions dampens the distributional consequence of trade.

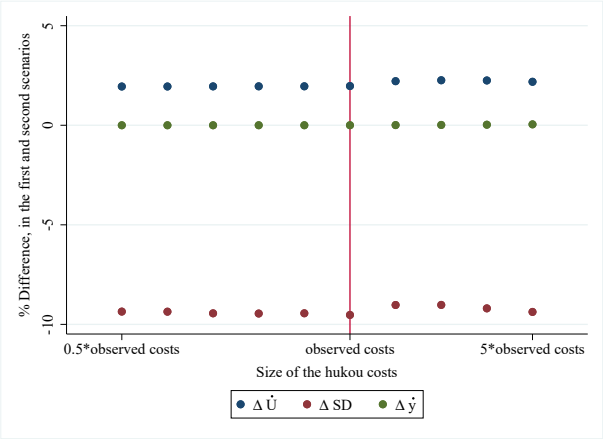


(a) Differences in equilibrium changes

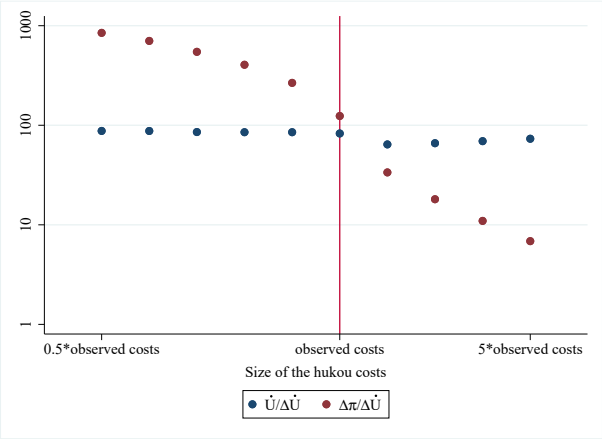
(b) Relative size of $\Delta\dot{y}$

Figure A3: Δ Gains from trade for different magnitudes of migration cost reductions

Finally, I provide some numerical results to support the above discussion. In Figure R.T1, I calibrate the Cobb-Douglas model and perform counterfactual analysis as in Section 5.3 of the paper. But I consider different degrees of reduction in migration costs, ranging 0.2 times to 5 times of the estimated hukou frictions. Similarly, in Figure R.T2, I consider different degrees of reduction in trade costs ranging from 0.2 times to 5 times the observed reduction in tariffs. As



(a) Differences in equilibrium changes



(b) Relative size of $\Delta\dot{y}$

Figure A4: Δ Gains from trade for different magnitudes of trade cost reductions

shown in Figures R.T1-(a) and R.T2-(a), the difference in regional income changes, $\Delta\dot{y}$, are close to zero in all cases. Furthermore, as suggested in Figures R.T1-(b) and R.T2-(b), $\Delta(\frac{\dot{y}_i}{P_i})$ is several orders of magnitude smaller compared to $\Delta\pi_{hi}$ and $(\frac{\dot{y}_i}{P_i})$. Therefore, consistent with the above theoretical analysis, the quantitative results suggest that reducing migration restrictions increases the aggregate gains from trade (i.e. $\Delta\dot{U} > 0$) and mitigates its distributional consequences (i.e. $\Delta SD < 0$). In particular, as shown in Figure R.T1-(a), the greater the reduction in migration costs, the greater the complementary effect between trade and migration cost reductions and the smaller the distributional consequences. In sum, the numerical exercise suggests that under the assumption of Cobb-Douglas, the claim that freer migration increases the gains from trade and weakens the distributional impact, holds over a large range of trade and migration cost reduction values, and the counterfactual equilibrium changes are consistent with the theoretical analysis.

E.2 Data for Calibration

This section provides a summary of the sources and the construction of all parameters used in the quantification section except for the hukou frictions, which is discussed in subsection 5.1.

Regions, sectors, and labor markets I calibrate the model to 31 regions, including 30 Chinese provinces and a constructed rest of the world, and 71 industries (using the same industry classification as in Section 2). Tibet is also excluded from the analysis due to a lack of data on trade flows between Tibet and other Chinese regions. Calibrating the model at the province level (rather than at the prefecture level) tends to underestimate both the distributional consequences of trade and the benefits of eliminating hukou frictions (which I discuss further in Section 4.3). Therefore, the corresponding quantitative results can be viewed as conservative estimates of the actual effects.

Tariff changes and revenues I take tariff changes directly from the empirical analysis. The sectoral trade elasticity θ_s is calculated based on the method developed by Caliendo and Parro

(2015). I provide the estimation details in Appendix E. In the quantitative exercise, I take tariff revenue into account and assume that it is redistributed equally to all citizens of a country.

Production data In line with the empirical analysis, I calculate the cost shares $\alpha_{is}(L)$, $\alpha_{is}(S)$, and $\alpha_{is}(k)$ for Chinese provinces using the 2002 Chinese National IO table. By doing so, I implicitly assume that the production structure is the same across all provinces.

I construct labor compensation $w_i L_{is}$ by sector and province for the year 2000 by multiplying provincial wages from the 2000 China Statistical Yearbook by sectoral employment from the 2000 population census. Then, using the cost shares, I compute province-specific output and structure rents for each sector. Finally, I deflate all three variables with a sector-specific constant so that the aggregated national output by sector equals the observed data.

For the rest of the world, I set the cost structure of each sector to that of the United States. To do so, I use the 2002 Standard Make and Use Tables from the Bureau of Economic Analysis (BEA) and concord it to my industry classification. To construct labor compensation for each sector, I first obtain the labor compensation data for the rest of the world from the OECD Inter-Country Input-Output (ICIO) Tables for 34 aggregated sectors classified according to the International Standard Industrial Classification (ISIC). Then, I split the data into the 71 industries by assuming that the share of each industry's labor compensation in the aggregated sectors to which they belong is the same as that of the United States. The structure compensation $r_i S_i$ and output R_{is} are then computed using the labor compensations and cost shares.

Bilateral trade flows Trade flows between each Chinese province and the rest of the world across non-service sectors are calculated based on the Chinese customs data for 2000.[51] The inter-provincial trade flows, as well as the international trade flows in service sectors, are calculated based on the production data and the 2002 Chinese Regional IO Tables. These tables report both inter-provincial trade and trade between Chinese provinces and the rest of the world for eight aggregated sectors. I first calculate each province's export share to a certain region (including itself) for these aggregated sectors. Next, for each of the 71 disaggregated sectors and provinces, I set export shares equal to that of the aggregated sector to which it belongs. Then, the trade flows of a disaggregated sector are calculated as its regional output times the export shares. When computing inter-provincial trade flows in non-service sectors, international trade flows are partialed out first.

In the model, I assume that trade is balanced; thus, income equals expenditure. When taking the model to the data, I follow Caliendo and Parro (2015) and calculate all counterfactuals while holding China's aggregate trade deficit as a share of world GDP constant at its 2000 level.

Share of final goods expenditure For Chinese provinces, I compute consumption shares directly using the 2002 Chinese National IO table. For the constructed rest of the world, the share

[51] With a slight abuse of terminology, non-service sectors refer to sectors that have positive trade flows reported in the Chinese customs data. Service sectors are sectors in which the Chinese National IO table documents positive trade flows but the Chinese customs data do not.

of income spent on goods from different sectors is calculated as:

$$\beta_{row,s} = \frac{\sum_{i \in N}(R_{is} - \sum_{k \in K} \alpha_{ik}(s) R_{ik}) - \sum_{i \neq row} \beta_{is} Y_{is}}{Y_{row,s}},$$

where *row* represents the constructed rest of the world.

E.3 Estimating Trade Elasticities

I calculate the sectoral trade elasticity θ_s based on the method developed by Caliendo and Parro (2015). Consider three countries indexed by i, j, and n, and denote location i's total expenditure on varieties from sector s, location j as X_{jis}. Substituting equation (7) into $\frac{X_{ijs}}{X_{ins}} \frac{X_{jns}}{X_{njs}} \frac{X_{nis}}{X_{jis}}$, I obtain:

$$\frac{X_{ijs}}{X_{ins}} \frac{X_{jns}}{X_{njs}} \frac{X_{nis}}{X_{jis}} = \left(\frac{\tau_{ijs}}{\tau_{ins}} \frac{\tau_{jns}}{\tau_{njs}} \frac{\tau_{nis}}{\tau_{jis}} \right)^{-\theta_s}. \tag{A19}$$

Caliendo and Parro (2015) show that if iceberg trade costs $\tilde{\tau}$ satisfy $\ln(\tilde{\tau}_{ijs}) = v_{is} + v_{js} + v_{ijs} + \epsilon_{ijs}$, where $v_{ijs} = v_{jis}$ and ϵ_{ijs} are orthogonal to tariffs t_{ijs}, all components of $\tilde{\tau}$ except ϵ_{ijs} cancel out, and the logged trade ratio can be expressed as:

$$ln \left(\frac{X_{ijs}}{X_{ins}} \frac{X_{jns}}{X_{njs}} \frac{X_{nis}}{X_{jis}} \right) = -\theta_s ln \left(\frac{1 + t_{ijs}}{1 + t_{ins}} \frac{1 + t_{jns}}{1 + t_{njs}} \frac{1 + t_{nis}}{1 + t_{jis}} \right) + \epsilon_{ijns}, \tag{A20}$$

where $\epsilon_{ijns} = \theta_s \left(\epsilon_{jis} - \epsilon_{ijs} + \epsilon_{ins} - \epsilon_{jns} + \epsilon_{njs} - \epsilon_{nis} \right)$ and is orthogonal to tariffs.

I estimate the θ_s sector-by-sector using specification (A20) for the year 2000. I collect data on trade flows and tariffs for 104 countries. Note that to construct the dependent variable, bilateral trade flows between three countries all have to be non-zero. Because I am estimating θ_s for more disaggregated industries than Caliendo and Parro (2015), the number of observations is limited by the number of positive sectoral trade inflows between countries. I am also restricted by the information on effectively applied tariff rates. Similar to Caliendo and Parro (2015), I impute the value of some countries to increase the sample size. If a country does not have effectively applied tariff data available in 2000, I impute this value with the closest value (in terms of date) available, searching up to four previous years, up to 1996. When effectively applied tariffs are not available in any of these years, I use the MFN tariffs of 2000. Data on trade flows are taken from the UN's Comtrade database for 2000. Values are recorded in US dollars for commodities at the HS6 product level, which I aggregate up to 43 tradable industries using concordance tables developed in this paper. Data on tariffs are taken from TRAINS for 1996-2000 and are at the HS6 level of disaggregation and were aggregated up to 43 tradable industries using an import-weighted average. The total number of observations is 407,923, with 9,487 observations per sector on average.

Table A12 presents the estimated θ_s and heteroskedasticity-robust standard errors using the full, 99%, and 97.5% sample. The 99% and 97.5% samples were constructed by dropping small trade

Table A12: Trade Elasticity Estimates

		Main	Full Sample			99% Sample			97.5% Sample		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No.	Industry Name	θ_s	θ_s	s.e.	N	θ_s	s.e.	N	θ_s	s.e.	N
1	Farming	0.52	0.52	(0.14)	15157	0.52	(0.14)	15156	0.52	(0.14)	15154
2	Forestry	3.37	3.37	(0.38)	5346	3.37	(0.38)	5346	3.38	(0.38)	5343
3	Animal Husbandry	0.02	0.02	(0.55)	2668	0.02	(0.55)	2668	0.01	(0.55)	2650
4	Fishery	1.30	-1.55	(0.85)	2140	-1.55	(0.85)	2140	-1.57	(0.85)	2136
6	Coal Mining and Dressing	0.55	0.55	(25.01)	86	0.55	(25.01)	86	0.55	(25.01)	86
7	Extraction of petroleum and Natural Gas	3.15	-6.67	(29.71)	22	-6.67	(29.71)	22	-6.67	(29.71)	22
8	Mining and Dressing of Ferrous Metals	3.15	-		8	-		8	-		8
9	Mining and Dressing of Nonferrous Metals	20.41	20.41	(17.81)	523	20.41	(17.81)	523	20.41	(17.81)	522
10	Mining and Dressing of Other Minerals	5.75	5.75	(1.06)	6133	5.75	(1.06)	6133	5.75	(1.06)	6131
13	Food Processing	3.90	3.9	(0.22)	13518	3.9	(0.22)	13517	3.9	(0.22)	13516
14	Food Production	2.03	2.03	(0.29)	4643	2.03	(0.29)	4642	2.01	(0.29)	4631
15	Beverages	4.48	-0.15	(0.43)	1481	-0.15	(0.43)	1481	-0.11	(0.43)	1461
16	Tobacco	0.54	0.54	(0.44)	232	0.54	(0.44)	232	0.49	(0.44)	230
17	Textiles	6.07	6.06	(0.28)	19947	6.07	(0.28)	19935	6.08	(0.28)	19924
18	Garments and Other Fiber Products	1.47	1.42	(0.26)	17909	1.47	(0.26)	17875	1.53	(0.26)	17825
19	Leather, Furs, Down and Related Products	7.16	7.16	(0.42)	11267	7.16	(0.42)	11267	7.14	(0.42)	11256
20	Timber Processing, etc.	10.71	10.71	(0.45)	10200	10.71	(0.45)	10198	10.69	(0.45)	10167
21	Furniture Manufacturing	0.33	0.33	(0.73)	10619	0.33	(0.73)	10615	0.31	(0.73)	10573
22	Paper-making and Paper Products	8.61	8.61	(0.45)	11777	8.61	(0.45)	11776	8.62	(0.45)	11775
23	Printing and Record Medium Reproduction	3.87	3.88	(0.46)	14726	3.87	(0.46)	14725	3.91	(0.47)	14685
24	Cultural, Educational and Sports Goods	0.95	0.95	(0.52)	9031	0.95	(0.52)	9031	0.94	(0.52)	9014
25	Petroleum Processing and Coking	13.50	13.5	(4.20)	2588	13.5	(4.20)	2588	13.5	(4.20)	2584
26	Raw Chemical Materials and Chemical Prod.	5.88	5.88	(0.35)	23710	5.88	(0.35)	23708	5.89	(0.35)	23676
27	Medical and Pharmaceutical Products	4.48	-3.77	(0.90)	11753	-3.77	(0.90)	11753	-3.78	(0.90)	11751
28	Chemical Fiber	7.56	7.56	(1.42)	3080	7.56	(1.42)	3080	7.48	(1.42)	3079
29	Rubber Products	4.48	-4.77	(0.53)	11792	-4.77	(0.53)	11792	-4.77	(0.53)	11780
30	Plastic Products	4.48	-0.91	(0.33)	18716	-0.92	(0.33)	18709	-0.92	(0.33)	18705
31	Nonmetal Mineral Products	3.76	3.77	(0.40)	14325	3.76	(0.40)	14322	3.76	(0.40)	14319
32	Smelting and Pressing of Ferrous Metals	5.37	5.37	(0.63)	9238	5.37	(0.63)	9238	5.38	(0.63)	9236
33	Smelting and Pressing of Nonferrous Metals	8.47	8.47	(0.84)	8796	8.47	(0.84)	8796	8.44	(0.84)	8794
34	Metal Products	1.96	1.95	(0.39)	18515	1.96	(0.39)	18475	1.96	(0.39)	18467
35	Ordinary Machinery	4.48	-2.25	(0.49)	17188	-2.25	(0.49)	17185	-2.27	(0.49)	17160
36	Equipment for Special Purposes	1.15	1.15	(0.50)	17728	1.15	(0.50)	17727	0.83	(0.51)	17706
37	Transport Equipment	0.18	0.19	(0.28)	13580	0.18	(0.28)	13579	0.19	(0.28)	13560
40	Electrical Equipment and Machinery	1.64	1.52	(0.43)	19632	1.64	(0.43)	19601	1.65	(0.43)	19598
41	Electronic and Telecommunications Equipment	2.34	2.34	(0.37)	18349	2.34	(0.37)	18348	2.21	(0.37)	18287
42	Instruments etc.	5.02	5.1	(0.46)	19775	5.02	(0.46)	19757	5.03	(0.46)	19644
43	Other Manufacturing	2.91	2.91	(0.34)	17096	2.91	(0.34)	17093	2.91	(0.34)	17089
76	Residential Services	4.07	-1.35	(2.78)	891	-1.35	(2.78)	891	-1.31	(2.81)	890
90	Culture and Arts	4.07	4.07	(1.32)	3252	4.07	(1.32)	3252	3.91	(1.35)	3218
93	Polytechnic Services	4.07	-		404	-		404	-		403

flows following Caliendo and Parro (2015). The coefficients have the correct sign in most cases, and the magnitude of the estimates varies considerably across industries.[52] Two industries, mining and dressing of ferrous metals and polytechnic services, have no variation in bilateral tariffs to identify the θ_s (if the tariff data only vary by importing countries, the logged tariff ratio equals zero). I use the estimates for the 99% sample as the estimates for calibration; for negative and empty estimates,

[52]The negative estimates are mainly driven by countries hit by the Asian financial crisis and China.

I replace them with the mean estimate of other industries in the same one-digit CSIC sector. I present in column (1) the final set of θ_s that are used for the quantitative exercises.

E.4 Prefecture-level Calibration

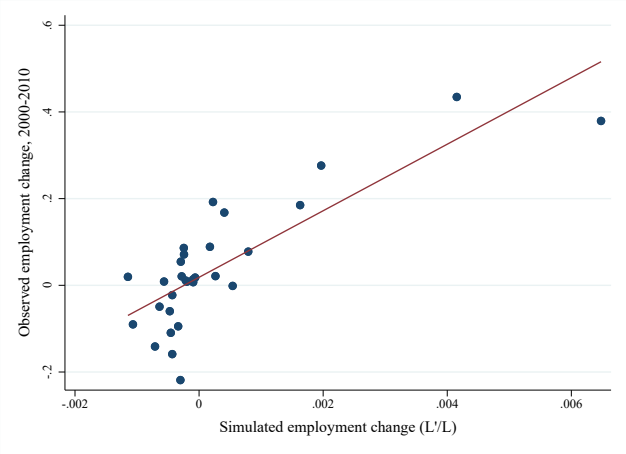
This section provides the calibration details for the prefecture-level quantification, the results of which are provided in Table 9 as a robustness check. To perform calibration at the prefecture level, I need to reconstruct the following variables compared to the analysis at the provincial level. They are 1) bilateral migration flows at the prefecture level; 2) labor and specific-factor compensations by industry and region; and 3) bilateral trade from region i, sector s to final consumption, and to intermediate usage of industry k in region j.

The 2000 census only asked about a person's prefecture of residence. For the location of the hukou registration, if it is in the same prefecture-level city as the place of residence, it can be seen from census questions. Otherwise, one can only know which province a person's hukou is from. I assign migrants to the prefecture-to-prefecture level as follows. First, I take adjusted cross-provincial bilateral migration described in Section 5.1 as a given and adjust the 2000 Census micro sample in the same way. That is, for non-native-born migrants who moved from location h to location i from 1995 to 2000 and obtained a household in i, their hukou location is set to their province of birth. Migration before 1995 was relatively rare, hukou policies are also very strict, hence it is safe to assume those individuals' hukou region is the same as their birth region. Secondly, I take the number of individuals living in a prefecture L_i and its hukou population from the national tabulation of the census. Based on L_i, I allocate the cross-provincial migration proportionally to province-to-prefecture. Then, I calculate L_{ii} as the share of local hukou holders implied from the census micro data times L_i. For L_{ih} in hukou prefectures other than i, I take the rest number of individuals and allocate them to prefectures proportionally based on each prefectures' hukou population in their associated provinces. In brief, I take L_{ii} directly from the data and assign proportionally the remaining inter-provincial migrants to pairs of prefectures based on the hukou population at the source location and the resident population at the destination.

To compute the prefecture-level labor and specific-factor compensations of a given industry, I first take their corresponding values at the province level and then split the values according to the employment share of each prefecture in that province and industry. Intuitively speaking, if a prefecture has a larger share of employment in an industry within its province, one should expect more of the value added in that industry to come from that prefecture. In some ethnic minority autonomous regions and prefectures with small populations, the majority of industries have zero employment. To ensure the quantification program functions properly (in particular, the matrix inverse has to be defined for calculations involving the equation 9), I combine these regions with neighboring prefectures and end up working with 272 prefecture cities. The rest of the variables are aggregated accordingly. Similarly, bilateral trade between production and use industries at the

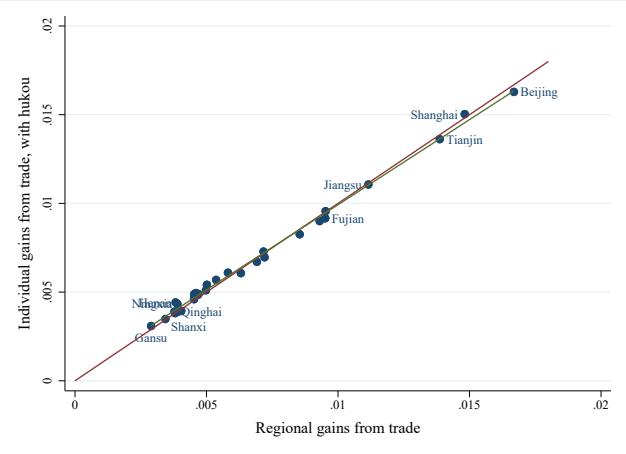
provincial level is allocated to prefecture pairs based on their corresponding employment shares in their associated provinces. Finally, final consumption at the provincial level is allocated to prefectures based on their share of the population in the province.

E.5 Additional Quantitative Results



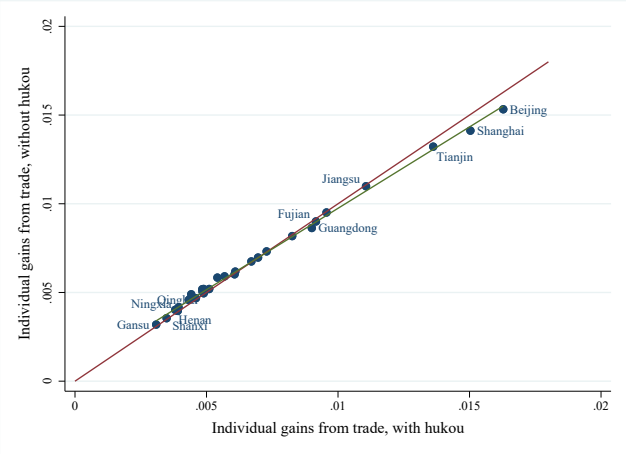
Notes: This figure plots the actual provincial employment changes (L'/L) from 2000 to 2010 against the employment changes predicted by the model. Correlation: 0.81; regression coefficient: 76.77; t: 7.41; R-squared: 0.66.

Figure A5: Calibrated and Observed Employment Changes Baseline Model



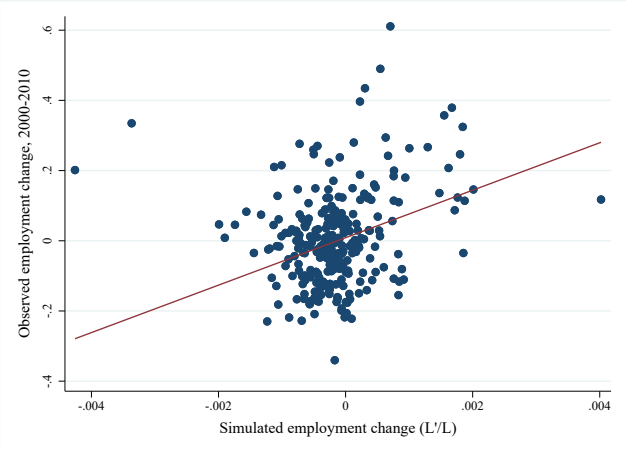
Notes: This figure plots individual welfare changes in terms of hukou province (individual gains from trade) against the changes in provincial real income per capita, i.e., regional gains from trade. The green line is the linear fit, and the red line is the 45 degree line.

Figure A6: Individual and Regional Gains from Trade (Cobb-Douglas Model)



Notes: This figure plots individuals' welfare changes from tariff reductions in terms of hukou provinces (individual gains from trade) with hukou abolition against the changes without hukou abolition. The green line is the linear fit, and the red line is the 45 degree line.

Figure A7: Individual Gains from Trade, with and without Hukou Frictions (Cobb-Douglas Model)



Notes: This figure plots the actual prefecture employment changes (L'/L) from 2000 to 2010 against the employment changes predicted by the model. Correlation: 0.33; regression coefficient: 67.59; t: 5.64; R-squared: 0.11. The regressions is weighted by initial employment level.

Figure A8: Calibrated and Observed Employment Changes (Prefecture)