AN ACCOUNTING OF THE DECLINE IN CHINA'S TRADE [*]

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Abstract

I present the fact of China's trade decline and elaborate some key mechanisms behind this phenomenon. To account for China's trade decline, I use a multi-sector, multi-region trade model. The model will also allow for inter-regional trade and inter-regional-sectoral labor mobility within China. The model feature three main types of time-varying and region-sector specific wedges: total factor productivity (TFP) wedges, trade cost wedges, labor mobility wedges. I then calibrate these "wedges" and conduct counterfactual experiments to account for and explain the change of China's trade share of GDP. I find that during the period 2002-2007, declining international trade cost in the heavy industry and TFP growth of foreign regions are the two dominant forces driving the increase in China's trade share of GDP. The TFP growth of China's regions is equally important, but it exerts its effects in a inverse direction, leading to a decrease in China's trade share. During the period 2007-2015, China's TFP growth are the dominant force behind the decrease in its trade share of GDP. At the sector level, during both periods, changes in TFP within the heavy industry sector play a crucial role in explaining the change in China's trade share of GDP. Moreover, through input-output linkages, changes in TFP within the services sector hold the same level of importance as changes within the heavy industry sector.

Keywords: china trade share decline; comparative advantage; specialization; labor flow; trade cost; TFP.

JEL Codes: F11, F43, O53.

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1. Introduction

Over the past 30 years, China's economy has grown enormously, with an average real GDP growth rate of 9.28% and an average real trade value growth of 11.17%. China is now the world's largest trading nation and the second-largest economy globally. A key feature of its growth has been its participation in the global economy, particularly since its entry into the WTO in 2001. Despite China's increasing importance in global trade, its trade share of GDP has been declining since the mid-2000s. In 2019, its average trade share of GDP drops back to 17.9%, compared to maximum level 32.2% in 2006 as showed in Figure 1. At the sector level, the heavy industry component of the China's trade share change accounts for the dominant part of total trade share change. As an important macroeconomic index, the trade share of GDP ratio reflects the extent to which a country's economy is connected to the global economy through foreign trade. As depicted in Figure 1, it generally exhibits an upward trend as the economy develops. This upward trajectory can be attributed to two factors: technological advancements that reduce transportation costs and the efforts of governments and international organizations in mitigating institutional expenses, such as tariff barriers for international trade. However, the change in China's average trade share is atypical. When compared to other countries, it grew rapidly during 2001-2006, with levels exceeding those of most developed and developing nations. After 2006, China's trade share began to decline rapidly, while many other countries maintained their previous trends or levels. During this same period, 2001-2015, accompanted with china's growing importance in the world economy, it's domestic market also changes dramaticly. The China's inner trade share of GDP is almost dobuled and it's cross province migrants is also changes largerly. China government has undertaken a progressive reform of household registration system during this period. This reform gradually release the regulation on within country migration, which is highly restricted before 2000s. Also, the rapid development of domestic infrastructure during 2000s influence both migrants and domestic trade from the geography perspective, which is also one of forces underlying China's GDP and trade growth.

The objective of this paper is to reveal the forces underlying China's declining trade share of GDP within the context of its growing trade with outside and increasing domestic economic integration. In particular, what are these forces drving the trade share change? which specific forces are more important? Does the interaction of several forces plays a significant role? To study this question, I perform a structural accounting decomposition using a multi-sector, multi-region trade model. It is a Ricardian trade model which builds on the framework from Eaton and Kortum (2002), Caliendo and Parro (2014). I introduce inter-regional labor flow across China's regions similar to Tombe and Zhu (2019). The model allow for inter-regional trade and inter-regional labor flow within China. Sepcially, In the model the main "shocks" are asymmetric inter-regional labor mobility shocks, international trade costs shocks, inter-regional trade costs shocks, sector-by-sector, as well as sectoral TFP shocks, region-by-region.

These shocks primarily affect China's trade through the lens of comparative advantage (CA) and specialization. For the mechanisms of the impact of Total Factor Productivity (TFP) forces on trade share, comparative advantage forces operate both within sectors and across sectors. For each of China's regions, aggregate TFP growth raises overall comparative advantage in more fraction of varieties in every sector. Also, when a particular sector within China's regions experiences higher TFP growth, the comparative advantage shifts from other sectors to the one with higher TFP growth. The forces of CA leads to China have CA and specialize in more variety of products, and foreign economies thus relatively specialize in less varieties. China product more variety of products and imports less. All else equal, it will leads to lower import share of GDP. This also leads to a lower ratio of exports share to GDP, even though the variety of exports will increase, partly due to TFP increases resulting in lower export prices. On the other hand, TFP increases in a specific sector can also influence the comparative advantages of other sectors in a different way through Input-Output Linkages. For instance, a TFP increase in the services sector results in lower marginal costs in the production of heavy industry, particularly when service products serve as the main intermediate inputs for heavy industry. As a result, heavy industry becomes more productive due to the reduced prices of service inputs. Given that heavy industry products account for a substantial portion of trade, the IO linkages imply that even though the services sector contributes a smaller share of total trade, the IO linkages can still lead to a significant decline in trade share. For the mechanisms of how changes in trade costs influence China's trade share of GDP, firstly, if trade costs between China's region and foreign economies decrease, both China and foreign economies specialize in a greater variety of products. From China's perspective, as foreign countries specialize in more varieties, the import share of GDP for China will increase. Similarly, because China's regions specialize in a greater variety of products, the export share of GDP will also increase. Secondly, if trade costs between China's regions decrease, each individual region in China can source a greater variety of products from other regions within the country. As a result, fewer varieties will be sourced from foreign countries. This will lead to a lower import share of GDP for China. This will also result in a lower ratio of export share to GDP, partially due to the decrease in inner trade costs leading to lower domestic prices.For the mechanisms of how labor mobility frictions influence China's trade share, under lower labor mobility frictions, labor will move from regions with low TFP to those with high TFP. As a result, high TFP regions will specialize even more due to labor inflow and their initially high TFP, while low TFP regions will specialize even less due to labor outflow and their initially low TFP. On average, China as a whole will specialize in more varieties, while foreign economies specialize in relatively fewer varieties. This will lead to a lower import share.

Due to the data availiability, the paper covers 11 regions (8 China regions plus 3 other regions), and 4 sectors for the year 2002, 2007 and 2015. I use the gravity equation way to calibrate the above shocks. I find that China underwent positive TFP growth in both analyzed time spans. Particularly, between 2007 and 2015, the weighted average TFP growth rate surpassed the preceding 2002 to 2007 period. China's weighted average internal trade costs demonstrated a decline across both intervals, with a slower decrease in the latter period. Additionally, China's weighted average external export trade costs also exhibited a decline in both periods but at almost the same speed. The weighted average external import trade costs displayed negligible change during 2002-2007 and a subsequent increase during 2007-2015. The weighted average migration frictions exhibit a decline in both periods, with the rate of decline slowing down in the later period.

To account the effects of each type of forces. I do counterfactual experiments like this: I solve the model holding individual shock at the base year level but allow all other shocks changes over time. I then compare this result with the baseline results. This approach enables me to quantify the change in China's trade share of GDP attributable to particular forces. I find that during the period 2002-2007, declining international trade cost and TFP growth of foreign regions are the two dominant forces driving the increase in China's trade share of GDP. The TFP growth of China's regions is equally important, but it exerts its effects in a inverse direction, leading to a decrease in China's trade share. During the period 2007-2015, China's TFP growth are the dominant force behind the decrease in its trade share of GDP. At the sector level, during both periods, changes in TFP within the heavy industry sector play a crucial role in explaining the change in China's trade share of GDP. Moreover, through input-output linkages, changes in TFP within the services sector hold the same level of importance as changes within the heavy industry sector. At the sector level, the change in international trade costs in the heavy industry is also key to explaining changes in trade share. However, it exerts significant effects only during the period from 2002 to 2007.

My paper is related to other relevant literature linking trade flows with geographical distribution of labor and economic activity within countries (Brandt, Tombe, and Zhu (2013), Allen and Arkolakis (2014), Caliendo, Parro, Rossi-Hansberg, and Sarte (2018), (Caliendo, Dvorkin, and Parro, 2019), Rodríguez-Clare, Ulate, and Vasquez (2020), Gai, Guo, Li, Shi, Zhu, et al. (2021)). I develop my model based on Caliendo and Parro (2014). Different from they model, my model feature both inter-regional trade and international trade, and incorporates inter-regional labor mobility frictions within the country, like Ahlfeldt, Redding, Sturm, and Wolf (2015), Redding (2016), Tombe and Zhu (2019). My paper is most closely related to Tombe and Zhu (2019), which study how policy reforms in China during 2000-2005 reduce the costs of both internal trade and migration and quantify its effects on welfare. My paper focus on explaining the change of China's trade share of GDP. I extend the periods further to the year 2015 and included more sectors. Additionally, my model includes migration in a parsimonious way to enhance computational feasibility and I solve the equilibrium at levels. The labor mobility fiction wedges in my model is region-to-region[1], which measures utility loss when people choose to migrate. Factors such as the physical distance, amenities of destination or source locations, institutional costs, and other policy induced welfare gains can all influence this utility lost ratio. My paper is also broadly related to the literature on the Chinese economy (Alessandria, Khan, Khederlarian, Ruhl, and Steinberg (2021), Campante, Chor, and Li (2023), Brandt and Holz (2006)). Brandt and Lim (2020) research the similar topics, they account for the drives of China's export change between 2000 and 2013 using Melitz type trade model. Our paper is different from these paper in that I incorporate internal migration and internal trade into the model. Most importantly, I focus on explaining China's trade share decline through structural decomposition, and there are no articles doing this yet.

The rest of the paper is organized as follows. Section 2 lays out the model and discuss the mechanisms. Section 3 describes the data, calibrates the main parameters and shocks, and then briefly talk about the shocks I backed out. Section 4 presents counterfactual structural decomposition experiments, and Section 5 concludes.

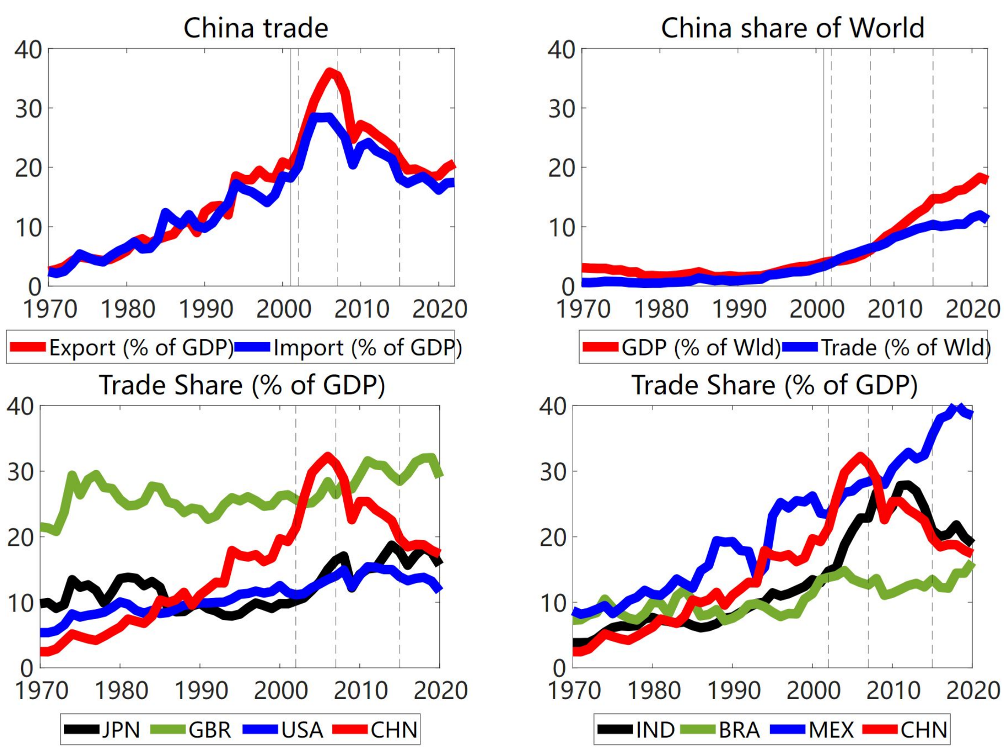
1. In Tombe and Zhu (2019), they introduce land into their production function and further incorporate land benefits into migration partial equilibrium. They also distinguish between-region migration and within-region rural-to-urban migration.

TABLE 1

China trade share change and migrants share change

	2002	***2007***	***2015***		***2002***	***2007***	***2015***
Import (% of GDP)	19.68%	25.78%	17.41%	***Export (% of GDP)***	23.46%	36.39%	20.03%
Agricultural Component	0.48%	0.80%	0.61%	*Agricultural Component*	0.37%	0.31%	0.14%
Light Industry Component	2.03%	1.36%	1.07%	*Light Industry Component*	5.21%	6.61%	3.17%
Heavy Industry Component	15.16%	20.77%	10.08%	*Heavy Industry Component*	12.98%	24.22%	13.13%
Services Component	2.01%	2.86%	5.65%	*Services Component*	4.91%	5.51%	3.59%
	2002	***2007***	***2015***		***2002***	***2007***	***2015***
Inner Trade (% of GDP)	26.95%	46.64%	50.53%	***China Trade (% of World)***	4.59%	6.72%	10.05%
Agricultural Component	1.37%	2.31%	2.23%	***China GDP (% of World)***	6.49%	9.24%	14.71%
Light Industry Component	4.51%	5.86%	6.11%				
Heavy Industry Component	16.33%	27.85%	24.41%		***2000***	***2005***	***2015***
Services Component	4.74%	10.61%	17.79%	***China Migrants (% of pop.)***	29.40%	34.00%	33.20%

Notes : Trade share of GDP ratios are calculated from the constructed unified Inter-Region Input-Output (IRIO) Table (constructed baseing on World IO table and China IO table) which embodies the industry-level bilateral trade flows across China's regions and foreign economies. China's internal trade share of GDP are calculated from total internal imports of all China's regions divided by China's GDP, here since internal exports must equal to internal imports, so I just use internal imports. China's trade share of world trade and GDP share of world GDP are from the WDI database. China's migrants share are from China's census data set. For detail of the data construction, see Appendix D.



Note:The solid line represents the year 2001 when China joined the WTO. The three dotted vertical lines represent the years 2002, 2007, and 2015, respectively. These are the years for which I conducted the counterfactual analysis.

Figure 1

China Trade and GDP Data

2. Model

The model I developed is a static multi-sector, multi-country, Ricardian trade model which builds on the framework from Eaton and Kortum (2002), Caliendo and Parro (2014). I introduce inter-regional labor flow across China's regions, similar to Ahlfeldt, Redding, Sturm and Wolf (2015), Redding (2016), Tombe and Zhu (2019). The model also incorporates both trade across China's regions and international trade. It encompasses N_0 regions within China, $N_1 = N - N_0$ foreign regions, and J sectors. All markets are perfectly competitive. Workers can move freely across sectors but and face mobility frictions across China's regions. Trade cost follow the usual "iceberg" form.

2.1. Production

The model consists of N_0 regions within China and $N_1 = N - N_0$ foreign regions. Each region has J sectors. The regions and sectors are linked by input-output linkages, and firms in region n produce a continuum of sector j goods denoted by $\omega^j \in [0,1]$, using CRS technology:

$$q_n^j\left(\omega^j\right) \equiv z_n^j\left(\omega^j\right) l_n^j\left(\omega^j\right)^{\gamma_n^j} \prod_{k=1}^{J} m_n^{k,j}\left(\omega^j\right)^{\gamma_n^{k,j}} \tag{1}$$

The non-tradable sectoral composite intermediate good Q_n^j in region n and sector j is consistent with the tradable intermediate good $r_n^j\left(\omega^j\right)$:

$$Q_n^j \equiv \left[\int_0^1 r_n^j\left(\omega^j\right)^{\frac{\sigma_j-1}{\sigma_j}} dj\right]^{\frac{\sigma_j}{\sigma_j-1}} \tag{2}$$

$q_n^j\left(\omega^j\right)$ is region n output of good ω^j ; $m_n^{k,j}\left(\omega^j\right)$ is the usage of sector k composite intermediate good in the production of region n goods ω^j and $\gamma_n^{k,j}$is the corresponding share in production function; $l_n^j\left(\omega^j\right)$ is the usage of labor in the production of region n goods ω^j and γ_n^j is the share of value-added in the production. The production technology satisfy $\sum_{k=1}^{J} \gamma_n^{k,j} + \gamma_n^j = 1$. The productivity of good ω^j in region n sector j is $z_n^j\left(\omega^j\right)$, which is the random variable follows a Fréchet distribution $F_n\left(\omega^j\right) = exp\left(-\lambda_n^j \omega^{-\theta}\right)$. λ_n^j govern the mean of the productivity, and θ govern the variance of productivity distribution [2].

2. a large value of λ_n^j means high average TFP, and a large value of θ means the low variance of productivity distribution or a weak force of comparative advantage.

2.2. *Internal Migration and Preference*

For each worker with registration place (*hukou*) in region m, the worker choose working place n to maximize their utility, the working place he choose is also his living place in the model. The final utility from migration is construct by three parts. Firstly, through the migration the worker can get higher real wage W_n in the new region, which means higher utility from consumption, $\mathcal{C}_n$. Secondly, there is a proportional ratio $\nu^{n,m}$ capturing utility loss when people choose to migrate out of they registration place, factors such as the physical distance, institutional costs, and amenities of destination or source locations can influence this utility lost ratio. Thirdly, the idiosyncratic term $z(\epsilon)$, which is preference shiftier for moving, capture the fact that preference on the same destination (n) are also heterogeneous across workers from the same source (m).

$$U^{n,m} \equiv \frac{z_{n,m}(\epsilon)}{\nu^{n,m}} U(\mathcal{C}_n) \tag{3}$$

Each worker is endowed with 1 unit of labor. For each worker registered in region m, if this worker choosing working in region n, the Cobb-Douglas utility is:

$$U(\mathcal{C}_n) \equiv \mathcal{C}_n \equiv \prod_{k=1}^{J} \mathcal{C}_n^{k\,\alpha_n^k}, \sum_{k=1}^{J} \alpha_n^k = 1 \tag{4}$$

$$\sum_k P_n^k \mathcal{C}_n^k = P_n \mathcal{C}_n = \mathcal{I}_n \tag{5}$$

$$P_n C_n = w_n L_n + D_n = I_n \tag{6}$$

$$\mathcal{C}_n L_n = C_n \tag{7}$$

$$\mathcal{I}_n L_n = I_n \tag{8}$$

For each individual people choosing to work in region n, his consumption on sector k composite intermediate good is $\mathcal{C}_n^k$, and his aggregate consumption or utility is defined as $\mathcal{C}_n$, and his wage rate is w_n. The total consumption for all workers in region n is C_n, and the total income for all region n worker is I_n. The price of sectoral composite intermediate good of region n sector k is P_n^k, which is same for people working in the same region n. Real income for each individual worker in region n is defined as $W_n \equiv \dfrac{w_n L_n + D_n}{P_n L_n}$. The number of labor in the region n is L_n.

The overall aggregate price level of region n is given by:

$$P_{n=}\prod_{j=1}^{J}\left[\frac{P_n^j}{\alpha_n^j}\right]^{\alpha_n^j} \tag{9}$$

Then, from Equation 4, Equation 5, the indirect utility function for a individual people from region m sector k choosing to work in region n is:

$$V(\epsilon)^{n,m}=\frac{z_{n,m}(\epsilon)W_n}{\nu^{n,m}} \tag{10}$$

The real income for people working in region n is W_n. For each worker ϵ. the idiosyncratic preference shifter $z_n(\epsilon)$ is i.i.d. across different destination and source locations, and follows *Fréchet distribution* with C.D.F[3]:

$$z_{n,m}(\epsilon)\sim G_{n,m}\left(z\right)=e^{-\epsilon^{-\kappa}} \tag{11}$$

Labor Market Equilibrium

Let $m^{n,m}$ denote the fraction of workers originally registered in region m who migrated to region n, where $\sum\limits_n m^{n,m}=1$. From law of large numbers, I can derive

$$m^{n,m}=\frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n\prime}^{N0}\left(\frac{W_{n\prime}}{\nu^{n\prime,m}}\right)^{\kappa}} \tag{12}$$

Given initial distribution of workers' registration region $\bar{L_m}$, the real income of destination regions, migration friction terms $\{W_n,\nu^{n,m}\}$, there exists a unique partial equilibrium that generate the labor allocation share $\{m^{n,m}\}$. Total labor at region (n) is

$$L_n=\sum_{m}^{N0}m^{n,m}\bar{L_m} \tag{13}$$

2.3. Trade cost, Price, and Equilibrium Condition

Trade is subject to trade costs shocks. In the model, the trade costs follow the usual "iceberg" form. One unit of a tradable good ω^j in sector j shipped from region i to region n requires $\kappa_{ni}^j\geq 1$ units in i, and the trade cost within region equal to 1, $\kappa_{ii}^j=1$. Factors such as geography, culture, language, tariff policy, or any relevant forces can create such kind of "

3. κ is defined as Migration Elasticity. A large value of κ means the low degree of preference disparity, higher elasticity of migration w.r.t the deterministic part (real income and labor flow cost).

barriers" or "distortion" and then generate the observed trade flow. The cost of a bundle of labor and sectoral composite intermediate good of region n sector j is

$$c_n^j = \Upsilon_n^j w_n{}^{\gamma_n^j} \prod_{k=1}^{J} P_n^{k\gamma_n^{k,j}}, where\ \Upsilon_n^j \equiv \prod_{k=1}^{J} \gamma_n^{k,j-\gamma_n^{k,j}} \gamma_n^{j\ -\gamma_n^j} \tag{14}$$

$$p_n^j\left(\omega^j\right) = \min_i \left[\frac{c_i^j \kappa_{ni}^j}{z_n^j\left(\omega^j\right)}\right] \tag{15}$$

The price of intermediate good ω^j is $p_n^j\left(\omega^j\right)$. From the *Fréchet distribution*, the price of sectoral composite intermediate good of region n sector j is

$$P_n^j \equiv \left[\int_0^1 p_n^j\left(\omega^j\right)^{1-\sigma^j} d\omega^j\right]^{\frac{1}{1-\sigma^j}} = A^j \Phi_n^{j\ -\frac{1}{\theta}} \tag{16}$$

where $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{(1-\sigma^j)}}$, $\Phi_n^j = \sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta}$.

Define total expenditures on good j by region n as X_n^j , and I have $P_n^j Q_n^j = X_n^j$. The expenditure by region n of sector j goods from region i is X_{ni}^j, with $X_n^j \equiv \sum_{m=1}^{N} X_{nm}^j$. Total revenue of country n on sector j goods is then $R_n^j = \sum_{i=1}^{N} X_{in}^j$. The expenditure share is defined as $\pi_{ni}^j \equiv \frac{X_{ni}^j}{\sum_{m=1}^{N} X_{nm}^j}$, and

$$\pi_{ni}^j = \frac{\lambda_i^j \left(c_i^j \kappa_{ni}^j\right)^{-\theta}}{\sum_{m=1}^{N} \lambda_m^j \left(c_m^j \kappa_{nm}^j\right)^{-\theta}} \tag{17}$$

Each composite good is used as an intermediate and as final consumption, total expenditure on a composite good in sector j, region n is:

$$X_n^j = \alpha_n^j I_n + \sum_{k=1}^{J} \gamma_n^{j,k} \left(\sum_{i=1}^{N} X_{in}^k\right) \tag{18}$$

where $\alpha_n^j I_n$ is final demand for good j by workers in region n, D_n^j is sectoral trade deficit, and the regional trade deficit $D_n \equiv \sum_j D_n^j$ is exogenous in the model.

$$w_n L_n + D_n = I_n \tag{19}$$

Under the exogenous trade deficit D_n, trade balance condition is:

$$\begin{aligned} \sum_{j=1}^{J}\sum_{i=1}^{N} X_{ni}^{j} - D_n &= \sum_{j=1}^{J}\sum_{i=1}^{N} X_{in}^{j} \\ or \quad \sum_{i=1}^{N} X_{ni}^{j} - D_n^{j} &= \sum_{i=1}^{N} X_{in}^{j} \end{aligned} \tag{20}$$

From the expenditure Equation (18) and trade balance condition (20), I get labor clearing condition:

$$w_n L_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j \tag{21}$$

2.4. Equilibrium

Given the model parameters $(\gamma_n^j, \gamma_n^{k,j}, \sigma^j, \alpha_n^k, \theta, \kappa)$, sectoral TFP and bilateral trade costs $(\lambda_n^j, \kappa_{ni})$, labor mobility frictions $(\nu^{n,m})$, and data on region n's trade deficit, initial total population and China region m's initial registration population $(D_n, L_n, \bar{L}_m)$, there exist unique values of labor migration share, expenditure share, and wage rate $\pi_{ni}^j, m^{n,m}, w_n$ that can solve the equations in Table 2.

TABLE 2
EQUILIBRIUM CONDITIONS

(F1)	$c_n^j = \Upsilon_n^j w_n^{\gamma_n^j} \prod_{k=1}^{J} P_n^{k\,\gamma_n^{k,j}}$; $\Upsilon_n^j \equiv \prod_{k=1}^{J} \gamma_n^{k,j\,-\gamma_n^{k,j}} \gamma_n^{j\,-\gamma_n^j}$	$\forall(n,j)$
(F2)	$P_n^j = A^j \left(\sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta}\right)^{-\frac{1}{\theta}}$; $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{(1-\sigma^j)}}$	$\forall(n,j)$
(F3)	$\pi_{ni}^j = \frac{\lambda_i^j \left(c_i^j \kappa_{ni}^j\right)^{-\theta}}{\sum_{m=1}^{N} \lambda_m^j \left(c_m^j \kappa_{nm}^j\right)^{-\theta}} = \lambda_i^j \left(A^j \frac{c_i^j \kappa_{ni}^j}{P_n^j}\right)^{-\theta}$	$\forall(n,j)$
(H1)	$P_n = \prod_{j=1}^{J} \left(\frac{P_n^j}{\alpha_n^j}\right)^{\alpha_n^j}$	$\forall(n)$
(H2)	$W_n \equiv \frac{I_n}{P_n L_n}$; $w_n L_n + D_n = I_n$	$\forall(n)$
(H3)	$m^{n,m} = \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}}$	$\forall(n,m)$
(H4)	$L_n = \sum_{m}^{N0} m^{n,m} \bar{L}_m$	$\forall(n)$
(M1)	$X_n^j = \alpha_n^j I_n + \sum_{k=1}^{J} \gamma_n^{j,k} \left(\sum_{i=1}^{N} X_{in}^k\right)$	$\forall(n,j)$
(M2)	$\sum_{j=1}^{J} \sum_{i=1}^{N} X_{ni}^j - D_n = \sum_{j=1}^{J} \sum_{i=1}^{N} X_{in}^j$	$\forall(n,j)$
(M2′)	$w_n L_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j$	$\forall(n)$

2.5. Discussion

To illustrate the mechanism of how exogenous shocks drive changes in trade share, I begin by analyzing a one-sector version of the model under free trade and homogeneous labor mobility costs, for which we have closed-form analytical solutions. There are N_0 regions within China, and $N_1 = N - N_0$ are foreign regions. I accordingly drop the sector subscripts. So, trade cost $\forall n, i \in \mathbb{N}$, $\kappa_{ni} = 1$ and migration cost $\forall n, m \in \mathbb{N}_0, n \neq m$, $\nu^{n,m} = \nu$.

$$\text{TradeShare}_{CHN} = \frac{1}{\beta}\left(1 - \sum_{i \in \mathbb{N}_0} \pi_{ni}\right) = \frac{1}{\beta}\left(\sum_{i \in \mathbb{N}_1} \pi_{ni}\right) \tag{22}$$

$$\pi_{ni} = (Z_i)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{-1} \tag{23}$$

$$\frac{w_n}{P_n} = (A\Upsilon)^{-1/\beta} L_n{}^{-1} (Z_n)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{1/\theta\beta} \tag{24}$$

where Z_n is defied as productive capacity of the economy n: $Z_n \equiv \lambda_n L_n{}^{\theta\beta}$.

Case 1: Friction-less labor flow $\forall n, m \in \mathbb{N}_0$ and $n \neq m$, $\nu^{n,m} = 1$.

$$\frac{L_n}{\sum_m^{N_0} \bar{L}_m} = \frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'}^{N_0} \left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}} \tag{25}$$

$$L_n = \frac{(\lambda_n)^{\frac{\kappa}{1+\kappa+\beta\theta}}}{\sum_{n'}^{N_0} (\lambda_{n'})^{\frac{\kappa}{1+\kappa+\beta\theta}}} \sum_{m}^{N_0} \bar{L}_m \tag{26}$$

So

$$\begin{aligned} TradeShare_{CHN} &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \pi_{ni}\right) \\ &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \frac{\left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}{\sum_{i\in\mathbb{N}_0} (\lambda_i)^{\frac{1+\kappa}{1+\kappa+\beta\theta}} + \sum_{i\in\mathbb{N}_1} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \\ &= \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \frac{(\lambda_i)^{\frac{1+\kappa}{1+\kappa+\beta\theta}}}{\sum_{i\in\mathbb{N}_0} (\lambda_i)^{\frac{1+\kappa}{1+\kappa+\beta\theta}} + \sum_{i\in\mathbb{N}_1} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \end{aligned} \tag{27}$$

Case 2: Labor flow with maximum friction $\forall n, m \in \mathbb{N}_0$ and $n \neq m$, $\nu^{n,m} = \infty$.

$$L_n = \bar{L}_n \tag{28}$$

So

$$\begin{aligned} TradeShare_{CHN} &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \pi_{ni}\right) \\ &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \frac{\left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}{\sum_{i\in\mathbb{N}} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \\ &= \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \frac{\left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}{\sum_{i\in\mathbb{N}} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \end{aligned} \tag{29}$$

The comparative advantage (CA) and specialization are the main parts of the story. From Equation 27 and Equation 29, China's trade share of GDP is determined by expenditure shares $\pi_n i$, where expenditure shares are determined by Z_i. Z_i is defined as the productive capacity of region i: $Z_i \equiv \lambda_i {L_i}^{\theta\beta}$.

In both the frictionless labor flow case and the infinite labor flow friction case, the TFP growth of the home region, i, will increase the productive capacity of that region. The increased productive capacity leads to China's regions having comparative advantages and specializing in a greater variety of products. As a result, foreign economies relatively specialize in fewer varieties, and China produces a greater variety while importing less. If China spends a fixed share on each variety, all else being equal, it will lead to a lower import share of GDP. There are also fewer exports as a share of China's GDP, even though the variety of exports will increase, partly because increased TFP also reduces export prices.

On the other hand, in the frictionless labor flow case, if the initial labor is relatively small, the increased TFP of the home region will attract labor inflow, further increasing the productive capacity of the home region and thereby decreasing China's trade share of GDP.

When comparing the infinite labor flow friction case with the frictionless labor flow case, reduced labor flow frictions make it easier for labor to migrate to regions with higher TFP, reducing resource misallocations. Overall, because China becomes more productive as a whole, the trade share of GDP will decrease.

Regarding the effects of internal and external trade costs, under trade cost frictions, higher internal trade costs or lower external trade costs will increase China's regions' expenditure shares with foreign regions, thus increasing China's trade share of GDP.

Another mechanism is omitted when analyzing based on a one-sector version of the model. In terms of how changes in China's individual sector TFP affect China's trade share of GDP, on one hand, it operates through the same mechanism analyzed earlier (the "Traditional TFP channel"). On the other hand, an increase in TFP in a particular sector can also influence other sectors' comparative advantages in a different way through Input-Output Linkages (the "IO-based TFP channel"). An increase in TFP in sector A leads to lower marginal costs in sector B's production, given that sector B heavily demands inputs from sector A. Consequently, sector B becomes more productive as well. If sector B's products constitute a significant portion of trade, then through the IO linkages, a sector accounting for only a smaller share of total trade can still lead to a significant decline in trade share.

3. Calibration

In this section, I demonstrate how to map the data to the model and calibrate exogenous time-invariant parameters (trade elasticity θ, labor flow elasticity κ, production shares $\gamma_n^{k,j}$, expenditure shares α_n^j), as well as time-varying shocks (labor mobility fictions $\nu^{n,m}$, trade costs κ_{ni}^j, TFP λ_n^j). Firstly, I calibrate the exogenous constant parameters that can be directly calculated from the data. Then, utilizing equations from the model and the calibrated time-invariant parameters, I derive the time-varying shocks and provide an interpretation for them. Finally, I present the derived shocks and incorporate these shocks into the model to demonstrate the fitness of my calibration.

The paper encompasses 8 regions in China, 3 foreign regions and 4 sectors over the periods 2002-2007 and 2007-2015. The 8 regions within China includes (Figure 2): A. Northeast, B. Beijing and Tianjin, C. Northern Coastal, D. Eastern Coastal, E. Southern Coastal, F. Central, G. Northwest, H. Southwest. The 3 foreign economy groups includes: an aggregate of Japan, Korea, and Taiwan (Asian3); G7 groups excluding Japan (G7-JPN); and an aggregate of the remaining countries, treated as the rest of the world (ROW). The sectors considered in my paper comprise agriculture, light industry, heavy industry, and services.

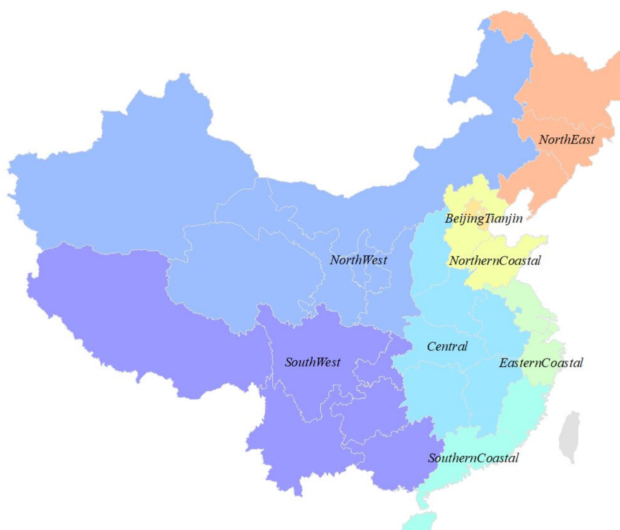


Figure 2
China Regions

The data used in this paper are from: the 5th National Census Data in 2000, the 6th National Census Data in 2005, the 7th National Census Data in 2015; Penn World Table (PWT) 10.0 (2002, 2007, 2015) (Feenstra, Inklaar, and Timmer, 2015); The World Input-Output Database (WIOD) (2002, 2007) (Timmer, Dietzenbacher, Los, Stehrer, and de Vries, 2015); OECD Inter-Country Input-Output (ICIO) Tables (2015) (OECD, 2021); The China Cross

Regional Input-Output Table (2002, 2007, 2015) (Zhang and Qi, 2012; Zheng, Zhang, Wei, Song, Dietzenbacher, Wang, Meng, Shan, Ou, and Guan, 2020); Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) (Head and Mayer, 2014). To calibrate the model, I need a unified multi-region multi-sector Input Output Table encompasses both Chinese and foreign regions. I create this table using the world IO tables (WIOD and OECD IO table) along with the China IO table. The constructed multi-region multi-sector Input-Output Table comprises 23 regions, including 8 Chinese regions, 15 foreign countries, and 4 sectors. Subsequently, I condense these tables into 8 Chinese regions, 3 foreign regions, and 4 sectors for the purpose of our research.

For detailed information regarding data sources, selected countries, sector concordance across various sources, and the methodology used to construct the unified multi-region multi-sector Input-Output Table, please refer to Appendix D.

3.1. Time invariant parameters

The sectoral expenditure data X^j_{ni} and sectoral value-added data V^j_n are derived from the constructed unified multi-region multi-sector Input-Output Table. The value of region i's exports of sector j goods to region n is M^j_{ni}, where $M^j_{ni} = X^j_{ni}$. Similarly, the value of region i's imports of sector j goods from region n is E^j_{ni}, where $E^j_{ni} = X^j_{in}$. The trade deficit of region n in sector j is denoted as D^j_n, and it is defined as $D^j_n = \sum_{i=1}^{N}(M^j_{ni} - E^j_{ni})$. The aggregate trade deficit of region n is represented as D_n, and it is calculated as $D_n = \sum_{j=1}^{J}\sum_{i=1}^{N} X^j_{ni} - \sum_{j=1}^{J}\sum_{i=1}^{N} X^j_{in}$. The gross production value of sector j goods in region n is denoted as Y^j_n, and it is computed as $Y^j_n = \sum_{i=1}^{N} M^j_{in}$. The value of region n's domestic sales of sector j goods is denoted as X^j_{nn}, and it is given by $X^j_{nn} = Y^j_n - \sum_{i\neq n}^{N} X^j_{in}$. The value added by region n from sector j is V^j_n, and the total value added by region n is denoted as V_n, where $V_n = w_n L_n = \sum_{j=1}^{J} V^j_n$. Furthermore, the value of demand for sector j goods in region n's production of sector k goods is represented as $V^{j,k}_n$, and the production share parameters:

$$\gamma^j_n = \frac{V^j_n}{Y^j_n}, \qquad \gamma^{j,k}_n = (1-\gamma^j_n)\frac{V^{j,k}_n}{\sum_{j=1}^{J} V^{j,k}_n} \tag{30}$$

The expenditure share α_n^j parameters are:

$$\alpha_n^j = \frac{Y_n^j + D_n^j - \sum_{k=1}^{J} \gamma_n^{j,k} Y_n^k}{I_n}, \qquad I_n = w_n L_n + D_n \tag{31}$$

I then take average on those parameters across year to filter out possible noise.

From Simonovska and Waugh (2014), I set trade elasticity term $\theta = 4$. From Tombe and Zhu (2019), I set labor flow elasticity term $\kappa = 1.5$. The elasticity of substitution across intermediate goods within sector j, $\sigma^j = 2$ for all sectors (Broda and Weinstein, 2006). The outcomes remain unaffected by this specific parameter selection.

3.2. Time varying shocks

In this section, I use the gravity equation derived from the model, and time invariant parameters I just calibrated to back out the TFP, trade cost and labor mobility friction. The expenditure share data π_{ni}^j, expenditure data $X_i^{j'}$, and value-added data V_n^j are from the constructed unified multi-region multi-sector Input Output Table. China's Labor flow share and Labor distribution across regions are from China Population Census data set. Country level total population data at the end of the year are from Penn World Table version 10.

From equation Equation 17, I can get the following structural gravity equation:

$$\ln\left(\frac{X_{nit}^j}{X_{nnt}^j}\right) = \ln\left(\lambda_{it}^j \left(c_{it}^j\right)^{-\theta}\right) - \ln\left(\lambda_{nt}^j \left(c_{nt}^j\right)^{-\theta}\right) - \theta \ln\left(\kappa_{nit}^j\right) \tag{32}$$

Following Tombe and Zhu (2019), I assume that unobserved trade cost terms κ_{ni}^j can be described by a symmetric component and an exporter-specific component. The symmetric component is well proxied by geographic distance:

$$\ln\left(\kappa_{ni}^j\right) = \mathrm{EX}_i^j + \beta^j \mathrm{lnDist}_{ni} + \epsilon_{ni}^j \tag{33}$$

X_{ni} is value of region n import sector j goods from region i. EX_n^j is exporter fixed effects in sector j's regression. $lnDist_{ni}$ is log of population-weighted geographic distance between region n and i, and defined as:

$$dist_{ni} = \sum_{r\in n}\left(\frac{\mathrm{pop}_r}{\mathrm{pop}_n}\right)\sum_{s\in i}\left(\frac{\mathrm{pop}_s}{\mathrm{pop}_i}\right) dist_{rs} \tag{34}$$

where pop_n is the population of region/sub-region n. We

To calculate the population-distance index, I first record the coordinate data of the capital of each of China mainland's 34 provinces and the capital of each of 226 foreign economies from Google Maps. Then I calculate the geographic distance between each pair of coordinates. Lastly, I compute the population-weighted distance between each pair of the 11 regions, which consist of 8 regions in China (each including several provinces) and foreign economy groups (each foreign economy group include several foreign economies). I use population data for 2000 which from China statistical year book and Penn World Table version 10.

Combine Equation 33 andEquation 32, I get the following structural equation:

$$
\begin{aligned}
\ln\left(\frac{X_{ni}^j}{X_{nn}^j}\right) &= \left\{\ln\left(\lambda_i^j\left(c_i^j\right)^{-\theta}\right) - \theta \mathrm{EX}_i^j\right\} + \left\{-\ln\left(\lambda_n^j\left(c_n^j\right)^{-\theta}\right)\right\} - \theta\beta^j \ln\mathrm{Dist}_{ni} - \theta\epsilon_{ni}^j \\
&= E_i^j + M_n^j + \Theta^j \ln\mathrm{Dist}_{ni} + \nu_{ni}^j
\end{aligned}
\tag{35}
$$

where $E_i^j \equiv S_i^j - \theta\ \mathrm{EX}_i^j$, $M_n^j \equiv -S_n^j$, $\Theta^j \equiv -\theta\beta^j$, and $S_n^j \equiv \ln\left(\lambda_n^j\left(c_n^j\right)^{-\theta}\right)$.

Step 1: Estimate $\tilde{E}_i^j$ and $\tilde{M}_n^j$

The 11 regions in the paper includes: 8 China regions, Asian 3, G-7 without Japan, and rest of world. I run the regression Equation 35 separately for each year and sector, then get estimated efixed effects $\tilde{E}_i^j$ and $\tilde{M}_n^j$.

Step 2: Trade cost shock

Based on estimated $\tilde{E}_i^j$ and $\tilde{M}_n^j$. The the location-sector specific states of technology term S_n^j can be estimated from $\tilde{S}_n^j = -\tilde{M}_n^j$. The exporter fixed effect $E\tilde{X}_i^j$ can be estimated from $E\tilde{X}_i^j = -\frac{\left(\tilde{E}_i^j + \tilde{M}_i^j\right)}{\theta}$. The available degrees of freedom imply that, in each sector, S_n^j identified only up to a normalization. Since my first region is China's Northeast region, I take Northeast region as the reference location, so $S_{Northeast}^j = 0$ for each year and each sector.

From Equation 35,

$$
\begin{aligned}
\ln\left(\frac{X_{ni}^j}{X_{nn}^j}\right) &= \tilde{E}_i^j + \tilde{M}_n^j - \tilde{\Theta} z_{ni} \\
&= \tilde{E}_i^j + \tilde{M}_n^j - \theta\tilde{\beta} z_{ni} = \ \tilde{S}_i^j - \theta\ E\tilde{X}_i^j - \ \tilde{S}_n^j - \theta\tilde{\beta} z_{ni} \\
&= \tilde{S}_i^j - \ \tilde{S}_n^j - \theta\left[E X_i^j + \tilde{\beta} z_{ni}\right] \\
&= \tilde{S}_i^j - \ \tilde{S}_n^j - \theta\left[\ln\left(\tilde{\kappa}_{ni}^j\right)\right]
\end{aligned}
\tag{36}
$$

So

$$
\tilde{\kappa}_{ni}^j = \{\left(\frac{X_{ni}^j}{X_{nn}^j}\right) exp(\tilde{S}_n^j - \ \tilde{S}_i^j)\}^{-\frac{1}{\theta}} \tag{37}
$$

and the sectoral price data can be calculated from

$$P_n^j = \ A^j \left[\sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j \right)^{-\theta} \right]^{-\frac{1}{\theta}} \ = \ A^j \left[\sum_{i=1}^{N} exp(S_i^j) \left(\kappa_{ni}^j \right)^{-\theta} \right]^{-\frac{1}{\theta}} \tag{38}$$

where $A^j = \Gamma \left(\frac{1+\theta-\sigma}{\theta} \right)^{\frac{1}{(1-\sigma)}}$, for $\forall j$.

From

$$\pi_{nn}^j = \lambda_n^j \left(\frac{A^j c_n^j}{P_n^j} \right)^{-\theta} = \lambda_n^j \ \left(c_n^j \right)^{-\theta} \left(\frac{A^j}{P_n^j} \right)^{-\theta} \tag{39}$$

I can calculate:

$$\tilde{P}_n^j = \ A^j \ \left[\left(\frac{exp(\tilde{S}_n^j)}{\pi_{nn}^j} \right) \right]^{-\frac{1}{\theta}} \tag{40}$$

Step 3: TFP shock

From $S_n^j \equiv \ln \left(\lambda_n^j \left(c_n^j \right)^{-\theta} \right)$, I can get

$$\tilde{\lambda}_n^j = \frac{exp\left(\tilde{S}_n^j\right)}{\left(\tilde{c}_n^j\right)^{-\theta}} \tag{41}$$

where $\tilde{c}_n^j = \Upsilon_n^j \tilde{w}_n^{\gamma_n^j} \prod_{k=1}^{J} \tilde{P}_n^{k\gamma_n^{k,j}}$, and $\Upsilon_n^j \equiv \prod_{k=1}^{J} \gamma_n^{k,j^{-\gamma_n^{k,j}}} \gamma_n^{j^{-\gamma_n^j}}$. From Equation 21:

$$\tilde{w}_n = \frac{\tilde{V}_n}{L_n} \tag{42}$$

where $\tilde{V}_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j$.

Step 4: Labor Mobility Friction shock

Assuming that the labor mobility cost change equal to 1 for people choose to stay where they are, so $\nu^{m,m} = 1$. From Equation 12, I back out labor mobility friction from:

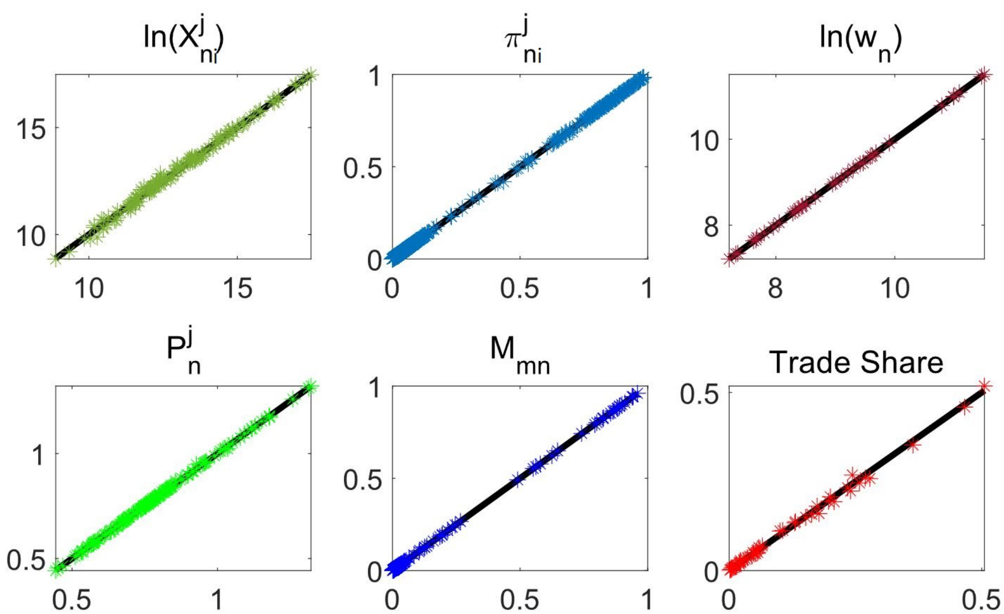
$$\tilde{\nu}^{n,m} = \left(\frac{\tilde{m}^{n,m}}{\tilde{m}^{m,m}} \right)^{-1/\kappa} \left(\frac{\tilde{W}_n}{\tilde{W}_m} \right) \tag{43}$$

Where $\tilde{W}_n = \dfrac{\tilde{w}_n L_n + D_n}{\tilde{P}_n L_n}$.

3.3. Model fit

This section shows the result of calibration. To demonstrate the effectiveness of the calibration, I compare the baseline model-generated data with the real world data. Then, I present each of time varying shocks and briefly discuss them.

I feed all the three types of time-varying shocks back to the model. Figure 3 compares the model-generated data (y-axis) with the real-world data (x-axis). The data points in Figure 3 includes the logarithmic value of expenditure X_{ni}^j, expenditure share π_{ni}^j, log value of wages w_n, Price P_n^j, migration share M_{mn}, trade share of GDP for each 11 regions, and trade share of GDP for China. The correlation between model generated data and the real-world counterpart is closely to the 45 degree line, indicating that the shocks I reverse-engineered perform well in replicating the real-world data.



Note: The scatter plots have model-generated value on the y axis and real data on the x axis with the 45 degree line on the diagonal.

Figure 3
Calibration Efficiency

TABLE 3
TFP change across sectors and regions

Average TFP	***07 v.s. 02***				***15 v.s. 07***			
Change	*China*	*A7-JPN*	*AS3*	*ROW*	*China*	*A7-JPN*	*AS3*	*ROW*
Aggregate	1.24	1.18	1.00	1.46	1.57	1.24	1.00	1.42
Agriculture	1.36	1.15	1.00	1.52	1.34	0.87	1.00	1.13
Light Industry	1.14	0.97	1.00	1.16	1.28	1.10	1.00	1.03
Heavy Industry	1.14	1.15	1.00	1.29	1.39	1.02	1.00	0.98
Services	1.30	1.20	1.00	1.53	1.78	1.29	1.00	1.63

Notes: This table displays the TFP changes in period 2002-2007 and period 2007-2015. The TFP change for Asian3 are normalized to 1. Here, I aggregate the regional sectoral TFP using average value-added shares (average across year 2002, 2007, and 2015) as weights to ensure changes in average TFP are not from changes in value added structures. For more details on calibrated TFPs change over time, see Appendix A.

TABLE 4
Average Trade Cost Change across sectors and regions

Average Trade	***China and China***		***Foreign and Foreign***	
Cost Change	*07 v.s. 02*	*15 v.s. 07*	*07 v.s. 02*	*15 v.s. 07*
Aggregate	0.83	0.96	0.96	0.93
Agricultural	0.84	0.92	0.98	1.10
Light Industry	0.85	1.01	1.03	1.05
Heavy Industry	0.82	1.04	0.98	1.00
Services	0.83	0.83	0.93	0.83
	China to Foreign		***Foreign to China***	
	07 v.s. 02	*15 v.s. 07*	*07 v.s. 02*	*15 v.s. 07*
Aggregate	0.73	0.77	1.00	1.16
Agricultural	0.74	0.64	1.04	1.56
Light Industry	0.74	0.74	1.14	1.34
Heavy Industry	0.70	0.89	0.98	1.12
Services	0.77	0.58	0.99	1.18

Notes: This table displays the average trade costs changes in period 2002-2007 and period 2007-2015. Here, I aggregate the sectoral trade costs using average expenditure share (average across year 2002, 2007, and 2015) as weights to ensure the changes in trade costs are not from changes in expenditure structures. For more details on calibrated sectoral trade costs changes over time, see Appendix A.

TABLE 5
MIGRATION FRICTIONS CHANGE

Migration frictions change									
07 v.s. 02	***Source***								
Destination	*Ave.*	*NE*	*BT*	*NC*	*EC*	*SC*	*CE*	*NW*	*SW*
Aggregate (Ave)	0.75	0.54	2.09	0.89	1.02	0.66	0.63	0.98	0.75
NorthEast (NE)	1.21	1.00	1.81	1.01	1.52	0.77	0.72	1.04	0.83
BeijingTianjin (BT)	0.26	0.24	1.00	0.31	0.44	0.28	0.22	0.35	0.20
NorthernCoastal (NC)	0.77	0.85	1.92	1.00	1.34	0.91	0.76	1.20	0.72
EasternCoastal (EC)	0.63	0.52	1.36	0.53	1.00	0.55	0.46	0.73	0.38
SouthernCoastal (SC)	1.17	0.96	2.53	1.00	1.58	1.00	0.82	1.27	0.80
Central (CE)	1.21	1.25	3.00	1.53	1.76	1.16	1.00	2.11	1.07
NorthWest (NW)	0.77	1.06	1.90	0.85	1.17	0.59	0.57	1.00	0.63
SouthWest (SW)	1.04	1.47	2.65	1.35	1.83	1.32	1.00	2.05	1.00
15 v.s. 07	***Source***								
Destination	*Ave.*	*NE*	*BT*	*NC*	*EC*	*SC*	*CE*	*NW*	*SW*
Aggregate (Ave)	0.96	0.66	0.23	1.05	1.41	0.57	1.49	0.64	1.26
NorthEast (NE)	1.36	1.00	0.31	2.21	1.57	0.94	2.21	1.17	1.35
BeijingTianjin (BT)	2.21	1.15	1.00	2.21	2.21	1.29	2.72	1.24	2.32
NorthernCoastal (NC)	0.91	0.64	0.30	1.00	0.82	0.39	1.04	0.58	1.06
EasternCoastal (EC)	0.63	0.46	0.26	0.89	1.00	0.56	1.31	0.44	1.14
SouthernCoastal (SC)	1.56	0.80	0.49	1.96	1.59	1.00	2.50	1.19	1.87
Central (CE)	0.46	0.30	0.11	0.64	0.43	0.26	1.00	0.43	0.71
NorthWest (NW)	1.51	0.72	0.30	1.44	1.45	0.69	2.09	1.00	2.14
SouthWest (SW)	0.62	0.34	0.29	0.71	0.63	0.37	1.19	0.45	1.00

Notes: This table displays the Migration frictions changes in period 2002-2007 and period 2007-2015. Here, I aggregate the migration frictions using average labor flow shares (average across year 2000, 2005, and 2015, due to data availability) as weights to ensure the changes in migration frictions are not from changes in labor flow shares.

Productivity wedges Table 3 plots the productivity change for different sectors and regions. The productivity changes of the Asian3 country group are normalized to 1. Overall, for aggregate China, its TFP growth is more relative to Asian3 in both periods. In the period 2002-2007, the TFP growth rate is even higher compared to the period 2007-2015 in all sectors except the agriculture sector. The average TFP change of China is 1.24 in the period 2002-2007 and 1.57 in the period 2007-2015.

Asymmetric Trade cost wedges Table 4 plots the weighted average trade cost change for different sectors and regions. In the period of 2002-2007, China's internal trade costs were declining uniformly across sectors. However, trade costs of China with foreign regions only decreased in the case of exports, with almost no change observed in imports. The trade costs between foreign and foreign also slightly decreased, except for the light industry sector. The trade cost decline for both internal trade and export trade are potentially due to the fact that China join to the WTO since December 2001, and also domestic market is also well development and more integrated with each other. Moving to the period between 2007 and 2015, China's internal trade costs did not decrease significantly, with a slight increase observed in the light and heavy industry sectors. A similar pattern is seen in foreign-to-foreign trade, except for the declining in services sector. China's export trade costs continued to decrease, while the costs associated with China's import trade experienced an increase.

Migration frictions changes Table 5 plots the migration frictions change during the two periods. At the aggregate level, the average migration frictions change is 0.75 during the period from 2002 to 2007 and 0.96 during the period from 2007 to 2015. One possible reason for the slower decline is that, from 2007 to 2015, China's local governments gradually relaxed their regulations on changing the registration province (Source province). As a result, it became easier to change the registration place compared to the previous period. The population that changed its registration province (Source province) cannot be captured by the registration-place based migration frictions. During the period from 2002 to 2007, it is evident that the migration friction (utility loss ratio) for people who migrate out of the Beijing and Tianjin area increases. In the period from 2007 to 2015, the migration friction for people who moved into the Beijing and Tianjin area also increases. These changes could potentially result from heterogeneous change of local government's migration policy, or amenities of different regions.

To summarize, the changes of three shocks behave differently in different periods, and most of changes are in line with the intuition. A complete story to explain the effects each of these shocks needs further counterfactual analysis.

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4. Quantitative Analysis

In this section, I quantitatively assess the contributions of each of these forces in influencing China's trade share change. There are a total of six types of shocks in the structural decomposition, including China's sectoral TFP shocks, China's regional initial labor supply shocks, migration friction shocks, China's internal trade cost shocks, China's international trade cost shocks, and all other forces (including foreign economies' sectoral TFP shocks, foreign economies' labor supply shocks, and foreign economies' trade cost shocks).

I find that during the period 2002 to 2007, international trade cost decline and foreign regions TFP growth are the two dominant forces behind China's trade share of GDP increase. The TFP growth of China's regions is equally important, but it exerts its effects in a inverse direction, leading to a decrease in China's trade share. While during the period 2007 to 2015, China's TFP growth are the dominant forces behind China's trade share of GDP decrease.

At the sector level, during both periods, changes in TFP within the heavy industry sector play a crucial role in explaining the change in China's trade share of GDP. Moreover, through input-output linkages, changes in TFP within the services sector hold the same level of importance as changes within the heavy industry sector. At the sector level, during the period from 2002 to 2007, the change in international trade costs in the heavy industry is also key to explaining changes in trade share.

The baseline results here means the results with all shocks happens. Table 6 shows the real data and the model generated data (baseline results) under different trade balance condition. Actually, the model generated data (baseline results) are good at mimic the real-world data. Given that trade deficit is exogenous to the model. When I do counterfactual, I deal with trade deficits in two different ways. Firstly, in the main part of the paper, I solve the model with all shocks and treat the trade deficits equal to zero. I then use the solved no-deficit world economy as baseline. Secondly, I calculate all counterfactual and baseline under fixed trade deficits to GDP ratio. I solve the model with zero trade deficit in all of counterfactual analysis in the main text, and put similar counterfactual analysis solved under exogenous trade deficit ratio as robust checks in the Appendix F. The conclusions drawn from these robustness checks are consistent with those presented in the main text.

Specifically, I do two types of counterfactual experiments. One type of counterfactual is that, I solve the model holding individual shock at the base year level but allow all other shocks changes over time. I then compare this result with the baseline results. The other type of counterfactual is that, I further decompose the contributions of some forces (China's TFP change, intranational trade cost change and international trade cost change, other forces) at the sector level or more disaggregated level. To be more detail, for each of these shocks, I solve the model holding particular disaggregated shocks at the base year level but allow all other other shocks changes over time. I then compare this result with the baseline results.

TABLE 6
Model fit

China Trade Share (% of GDP)		***Data***	***Model***	
			Exogenous trade deficits	*Trade balance*
			Basline 1	*Basline 2*
Import (% of GDP)	*2002*	19.68%	19.43%	22.09%
	2007	25.78%	24.58%	29.86%
	2015	17.41%	18.08%	19.59%
Export (% GDP)	*2002*	23.46%	23.19%	-
	2007	36.39%	35.25%	-
	2015	20.03%	20.69%	-
Internal trade (% of GDP)	*2002*	26.95%	26.05%	23.96%
	2007	46.64%	45.88%	45.79%
	2015	50.53%	51.79%	50.96%

4.1. Decompose trade share of GDP change

Table 7 illustrate the results of structural decomposition for six different types of forces plus a aggregate of all forces. For each force, I present both average marginal effects and marginal effects. The average marginal effects means the average effects across all 32 ($= 2^6/2$) possible pairs of permutations. The share of change column records the individual force's average marginal effect relative to the sum of all six average marginal effects. The standard deviation column reports the standard deviation of each individual force's effects, calculated from all 32 possible pairs of permutations of each individual force's effects. The marginal effects represent the difference between baseline results and the results of a case where a particular force is held constant at the base-year level while other forces change as usual. These effects are calculated from each pair of permutations.

During the period from 2002 to 2007, the primary factor explaining the increase in China's trade share was the decline in international trade costs, leads to approximately 10.78 percentage points (p.p.) trade share of GDP increase. The second significant factor was the aggregation of other forces, including foreign economies' TFP change, foreign economies' labor supply change, and change in trade costs in foreign economies, primarily driven by foreign regions' TFP growth, contributing to a decline of around 7.83 p.p. in China's trade share of GDP. The forces of China's TFP growth are equally important but exert their effects inversely. They reduce China's trade share of GDP by about 8.87 p.p. The effects of other types of forces align with our expectations but are relatively small in size.

Moving to the period from 2007 to 2015, China's TFP increase emerged as the main driving force which results to about 15.2 p.p. of China's trade share of GDP decline. Other forces, including foreign economies' TFP change, foreign economies' labor supply change, and change in trade costs in foreign economies, all together also held significance but exerted their effects inversely, resulting in an increase of about 4.88 p.p. in China's trade share of GDP. The effect of the rest of forces were as anticipated but relatively modest in magnitude.

To summarize, during the period 2002 to 2007, international trade cost decline and foreign regions TFP growth are the two key forces behind China's trade share of GDP increase. The TFP growth of China's regions is equally important, but it exerts its effects in a inverse direction, leading to a decrease in China's trade share. While during the period 2007 to 2015, China's TFP growth are the dominant forces behind China's trade share of GDP decrease. A complete story to quantify contributions of some key forces (China's TFP change, intranational trade cost change and international trade cost change, other forces) at the sector level or more disaggregated level needs further counterfactual analysis.

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TABLE 7
COUNTERFACTUAL EXPERIMENTS UNDER ZERO TRADE BALANCE CONDITION

Panel A	Average Marginal effects						Marginal effects	
07 v.s. 02	Trade Share of GDP (p.p. change)		Share of change		Standard deviation (-)		Trade Share of GDP (p.p. change)	
	External	Internal	Ex.	In.	Ex.	In.	Ex.	In.
All Forces	7.78	21.83	-	-	-	-	7.78	21.83
TFP	-8.87	1.44	-112.34%	6.66%	2.76	1.02	-12.55	2.04
Demographic								
Migration firction	1.67	0.60	21.15%	2.75%	0.38	0.54	1.99	1.01
Population growth	-0.32	0.03	-4.01%	0.12%	0.09	0.05	-0.36	0.08
Trade cost								
Intranational	-2.39	22.29	-30.32%	103.03%	0.40	0.89	-2.31	21.36
International	10.78	-1.64	136.47%	-7.60%	2.40	0.66	9.86	-1.65
Other forces	7.03	-1.07	89.05%	-4.96%	2.08	0.36	6.08	-1.42
Panel B	Average Marginal effects						Marginal effects	
15 v.s. 07	Trade Share of GDP (p.p. change)		Share of change		Standard deviation (-)		Trade Share of GDP (p.p. change)	
	External	Internal	Ex.	In.	Ex.	In.	Ex.	In.
All Forces	-10.28	5.16	-	-	-	-	-10.28	5.16
TFP	-11.54	2.14	101.62%	42.48%	1.72	2.74	-10.75	-0.12
Demographic								
Migration firction	-2.18	-0.50	19.19%	-9.99%	0.52	0.64	-1.84	0.14
Population growth	-0.58	0.29	5.14%	5.68%	0.15	0.29	-0.47	-0.07
Trade cost								
Intranational	-0.24	2.09	2.15%	41.57%	0.48	2.66	-0.24	-0.41
International	-1.68	-2.08	14.83%	-41.35%	4.05	0.81	-4.47	-1.42
Other forces	4.88	3.10	-42.94%	61.61%	4.25	0.68	0.37	2.25

Notes: This table decomposes the changes in the international and intranational trade shares of GDP into contributions from six types of shocks: China's sectoral TFP shocks, China's regional initial labor supply shocks, migration friction shocks, China's internal trade cost shocks, China's international trade cost shocks, and all other forces (including foreign economies' sectoral TFP shocks, foreign economies' labor supply shocks, and foreign economies' trade cost shocks). For each force, I report the average marginal effects across all 32 ($= 2^6/2$) possible pairs of permutations . The share of change is the individual force's average marginal effect relative to the sum of all average marginal effects. The standard deviation column reports the standard deviation of the individual force's effects, calculated from all 32 possible pairs of permutations. The marginal effects represent the change in trade share when a particular force is kept fixed at the base-year level while other forces change as usual. These effects are calculated from one pair of permutations.

4.2. Decompose trade share of GDP change at sector level

This section, I further decompose the contributions of China's TFP changes, internal trade cost changes, international trade costs changes, and other forces at more disaggregated level. The results of the structural decomposition at the sector level or a more disaggregated level are presented in Table 8. The marginal effects are the differences between the baseline results and the results of a case where a particular sub-force is kept fixed at the base year level, while the others change as usual.

In the period 2002 to 2007, according to earlier analysis, two dominant forces were identified behind the increase in China's trade share of GDP: the decline in international trade costs and the aggregation of the changes other forces. At the sector level, because heavy industry's trade accounts for a major portion of China's total trade, the decline in international trade costs in the heavy industry sector is the main force driving changes in trade share. This leads to a decrease of 6.74 p.p in China's trade share of GDP. Among the three shocks encompassed in the "Other shocks" category, the primary driving force was foreign TFP growth. This force contributed to a 5.8 p.p increase in China's trade share. Additionally, China's own TFP growth forces are of equal significance but exert their effects inversely. At the sector level, China's heavy industry TFP growth is the main force that leads to a decrease in trade share by 8.42 p.p. Despite services trade accounting for only a small part of China's total trade, through IO linkages and TFP growth in services per se, services' TFP growth is equally important. This leads to an increase in China's trade share by 8.59 p.p.

During the period from 2007 to 2015, China's TFP growth was the dominant force behind the decrease in China's trade share of GDP. At the sector level, the increase in China's TFP within the heavy industry sector led to a decrease in the trade share of GDP by 8.63 p.p. The growth of TFP in the services sector, facilitated by IO linkages and TFP growth within the services per se, resulted in an even larger decrease in the trade share by 13.96 p.p.

To summarize, at the more disaggregated level, during both periods, changes in China's TFP within the heavy industry sector play a crucial role in explaining the change in China's trade share of GDP. Moreover, through input-output linkages, changes in TFP within the services sector hold the same level of importance as changes within the heavy industry sector. During the period 2002-2007, TFP forces exerts its effects in a inverse direction, leading to a decrease in China's trade share. The change in international trade costs in the heavy industry is key to explaining increase in trade share. The Foreign TFP growth is second important forces driving China's trade share increase.

TABLE 8

Counterfactual experiments under zero trade balance condition, sectoral decompose

Panel A	Decompose Marginal effects at sector level				
07 v.s. 02	Trade Share of GDP (p.p. change)				
	External	Internal		External	Internal
All Forces	**7.78**	**21.83**	***TFP***	**-12.55**	**2.04**
Other forces	**6.08**	**-1.42**	Agriculture	-0.37	0.05
Foregin TFP	5.80	-1.47	Light industry	-1.50	0.47
Foregin trade cost	-0.41	0.17	Heavy industry	-8.42	5.41
Foregin labor	0.76	-0.14	Service	-8.70	-4.12
International Trade cost	**9.86**	**-1.65**	***Intranational Trade cost***	**-2.31**	**21.36**
Agriculture	-0.24	0.00	Agriculture	0.01	0.88
Light industry	0.63	-0.14	Light industry	-0.12	2.69
Heavy industry	6.74	-0.23	Heavy industry	-1.98	10.67
Service	0.56	-0.78	Service	0.04	5.72
Panel B	Decompose Marginal effects at sector level				
15 v.s. 07	Trade Share of GDP (p.p. change)				
	External	Internal		External	Internal
All Forces	**-10.28**	**5.16**	***TFP***	**-10.75**	**-0.12**
Other forces	**0.37**	**2.25**	Agriculture	-4.70	-0.78
Foregin TFP	0.67	2.11	Light industry	-0.90	0.03
Foregin trade cost	-0.68	0.25	Heavy industry	-8.63	5.24
Foregin labor	0.56	-0.07	Service	-13.96	-4.31
International Trade cost	**-4.47**	**-1.42**	***Intranational Trade cost***	**-0.24**	**-0.41**
Agriculture	-1.83	-0.26	Agriculture	0.01	-0.17
Light industry	-0.39	0.08	Light industry	0.04	-1.21
Heavy industry	-0.92	1.00	Heavy industry	0.27	-3.56
Service	-4.85	-1.84	Service	-0.06	2.36

Notes: This table decomposes the changes in the international and intranational trade shares of GDP, attributing them to various factors such as China's TFP change, changes in intranational trade costs, and changes in international trade costs at the sector level. Additionally, it also decompose the 'Other forces' at a more disaggregated level. For each of these shocks, the model is solved while holding the shocks specific to a particular sector or more dis-aggregated shocks at the base year level, while allowing all other shock changes to occur over time. I then compare this result with the baseline case.

5. Conclusion

I present the facts of China's trade share of GDP change during the period from 2002 to 2015. I further decompose China's trade share of GDP change at the sector level and find that the change in the heavy industry sector accounts for the main part of China's total trade share of GDP change. To explain the mechanism behind China's trade share change, I employ a static multi-sector, multi-country, Ricardian model of trade featuring Input-Output linkages, international trade, inter-regional trade within China, labor migration frictions across regions within China. Under this framework, I focus on the role of six driving forces, including China's sectoral TFP shocks, China's migration friction shocks, China's regions' labor supply shocks, China's intranational trade cost shocks, China's international trade cost shocks, and all other forces (including foreign economies' sectoral TFP shocks, foreign economies' labor supply shocks, foreign economies' trade cost shocks).

The primary mechanism under China's trade share of GDP change is comparative advantage (CA) and specialization, which exerts its effects mainly through TFP shocks and trade cost shocks. For the mechanisms of how changes in TFP influence China's trade share of GDP, on the one hand, When a particular sector within China's regions experiences higher TFP growth, the forces of CA leads to China have CA and specialize in more variety of products, and foreign economies thus relatively specialize in less varieties. China product more variety of products and imports less. All else equal, it will leads to lower import share of GDP. This also leads to a lower ratio of exports share to GDP, even though the total value of exports will increase, partly due to TFP increases resulting in lower export prices. On the other hand, TFP increases in a specific sector can also influence the comparative advantages of other sectors in a different way through Input-Output Linkages. For instance, a TFP increase in the services sector results in lower marginal costs in the production of heavy industry, particularly when service products serve as the main intermediate inputs for heavy industry. As a result, heavy industry becomes more productive due to the reduced prices of service inputs. Given that heavy industry products account for a substantial portion of trade, the IO linkages imply that even though the services sector contributes a smaller share of total trade, services TFP increase can still lead to a significant decline in trade share.

For the mechanisms of how changes in trade costs influence China's trade share of GDP, firstly, if trade costs between China's region and foreign economies decrease, both China and foreign economies specialize in a greater variety of products. From China's perspective, as foreign countries specialize in more varieties, the import share of GDP for China will increase. Similarly, because China's regions specialize in a greater variety of products, the export share of GDP will also increase. Secondly, if trade costs between China's regions decrease, each individual region in China can source a greater variety of products from other regions within the country. As a result, fewer varieties will be sourced from foreign countries. This will lead to a lower import share of GDP for China. This will also result in a lower ratio of export share to GDP, partially due to the decrease in inner trade costs leading to lower domestic prices.

The model covers 8 China regions, 3 foreign economy groups and 4 sectors over the period 2002-2007 and period 2007-2015. The model replicates the China's trade share of GDP change very well. The counterfactual exercises shows that during the period 2002 to 2007, international trade cost decline and foreign regions TFP growth are the two dominant forces behind China's trade share of GDP increase. China's regions TFP growth are same import during this period but it driven trade share of GDP down. While during the period 2007 to 2015, China's TFP growth are the dominant forces behind China's trade share of GDP decrease. At the sector level, in both periods, the heavy industry sector is the key to explain China's trade share of GDP change, and through IO linkages, services sector TFP change is also same important even though services trade only accounts for small part of China's total trade. During the period from 2002 to 2007, the change in international trade costs in the heavy industry is also key to explaining increases in trade share.

In the counterfactual experiments, trade deficit to region's GDP ratio is treated as zero or exogenous to the agents. Allowing endogenous trade deficit with a dynamic trade model would give more insight into how borrowing tendency cross regions have any connection with the trade share of GDP change. Also, neglect the computational complexity, I can extend the groups of China regions, foreign economies and sectors, to get more detail information at both regional and sectoral level. I leave these and other exercises for future research.

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Appendix A: Additional Figures

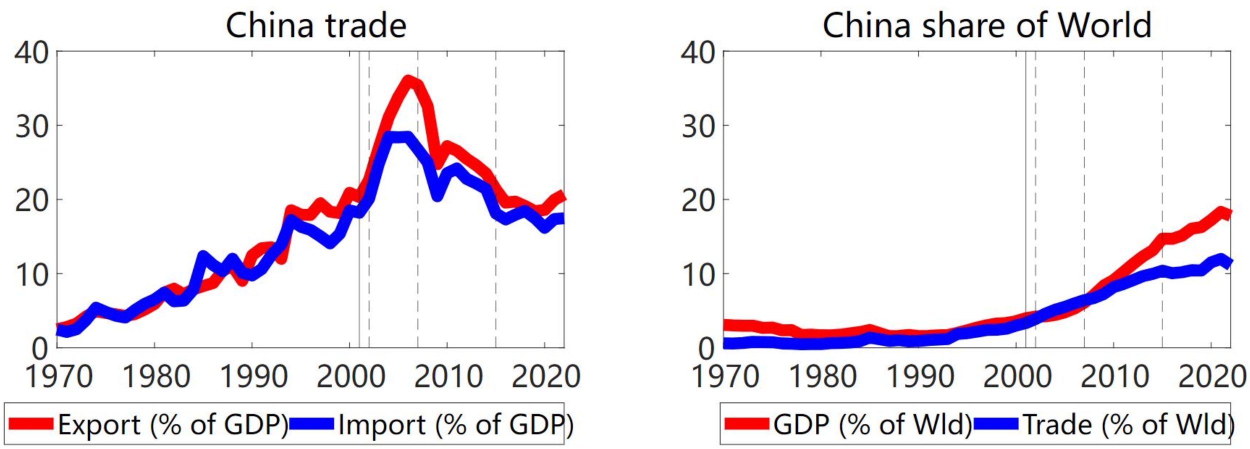
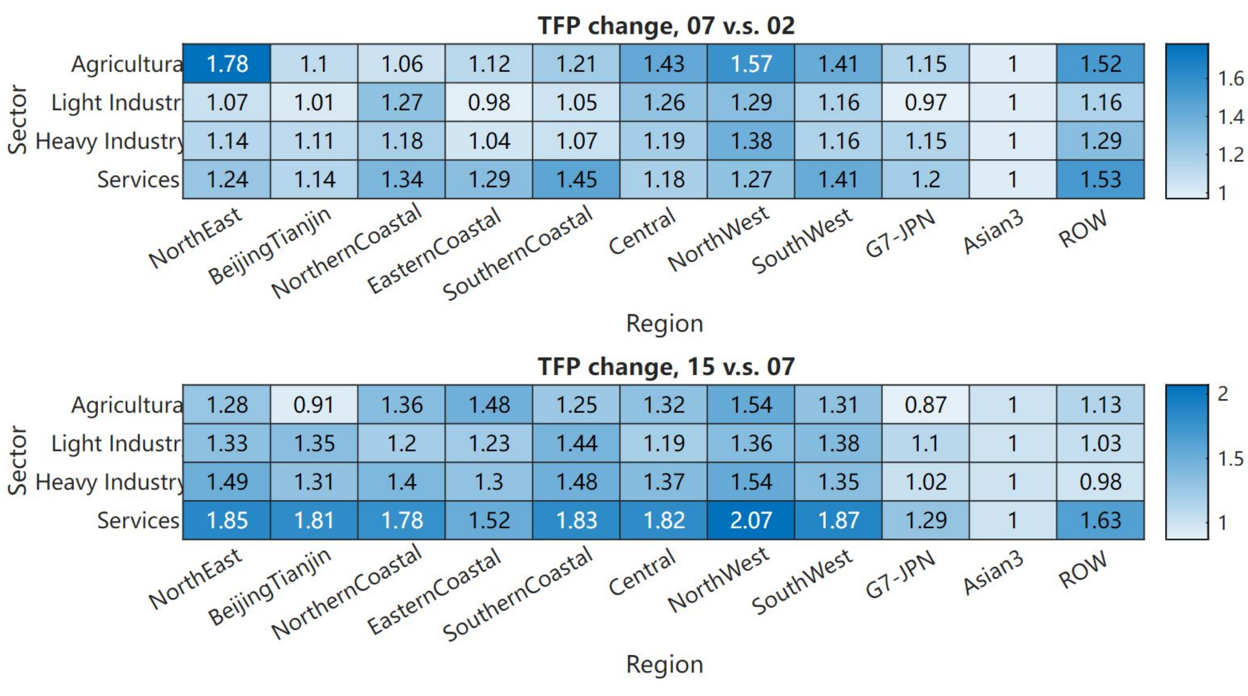
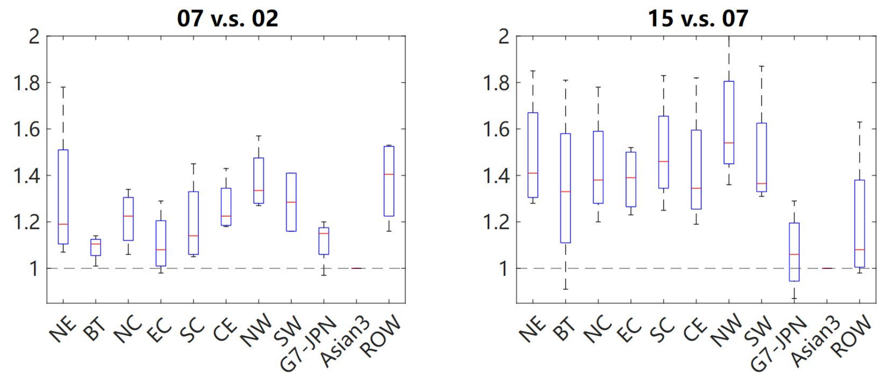


Figure A.1
China Trade and GDP Data



Notes: The productivity change of the Asian3 are normalized to 1.

Figure A.2
Calibration Results: TFP ($\lambda^{1/\theta}$) Change



Notes: The productivity change of the Asian3 are normalized to 1.

Figure A.3

Calibration Results: TFP ($\lambda^{1/\theta}$) Change

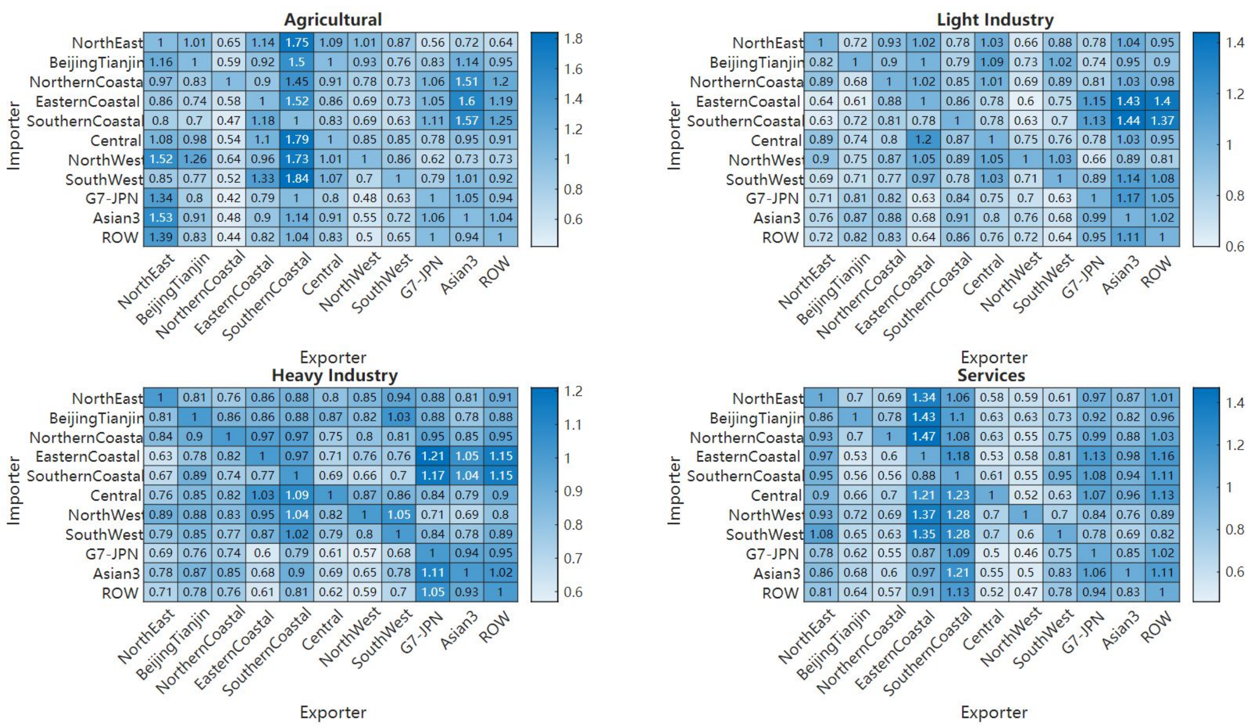


Figure A.4

Calibration Results: Trade Cost Change - 2007 v.s. 2002

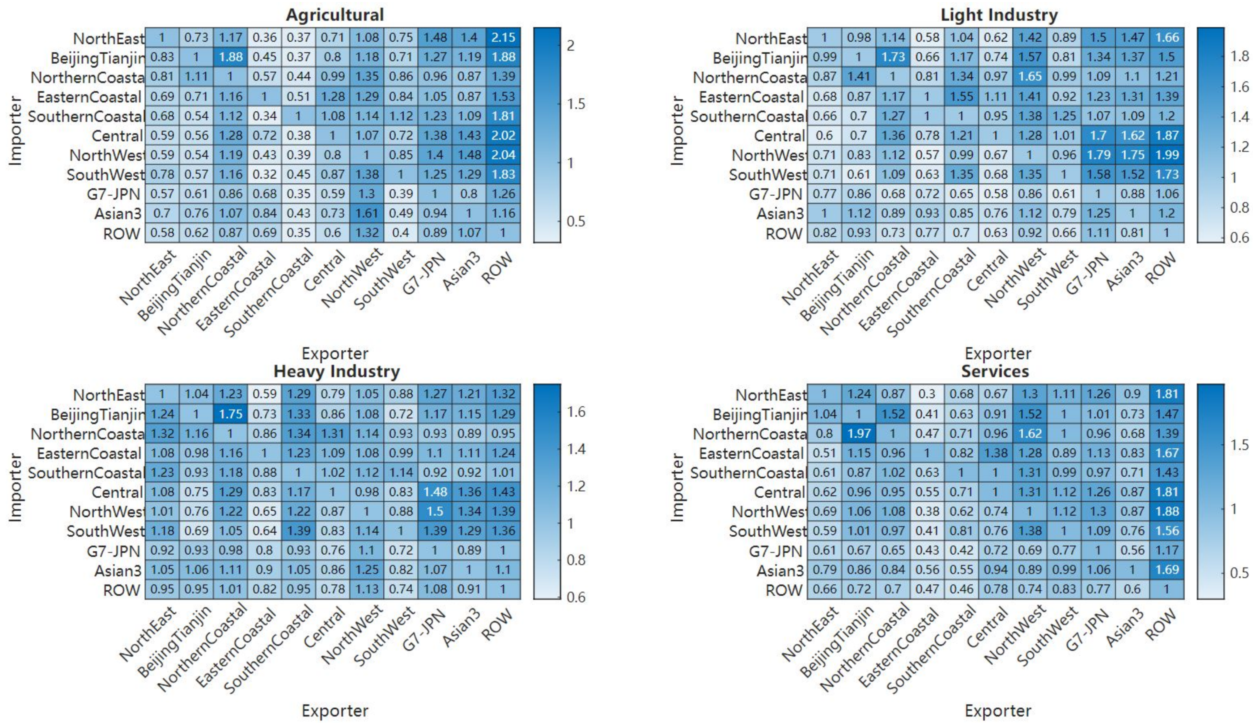
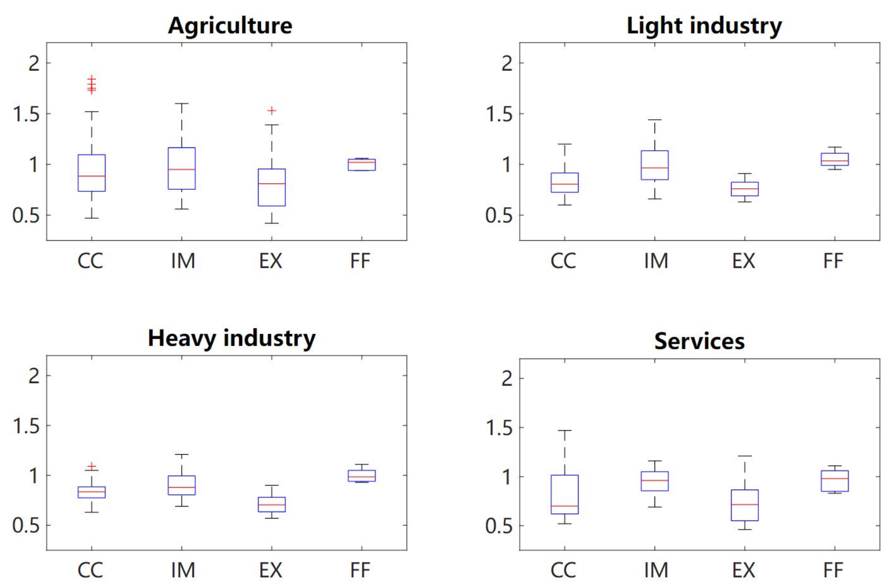
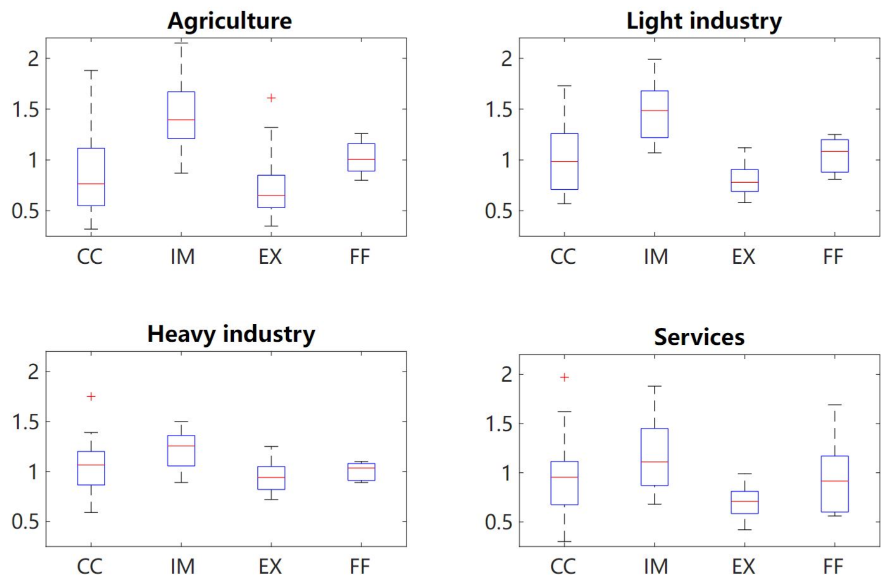


Figure A.5
Calibration Results: Trade Cost Change - 2015 v.s. 2007



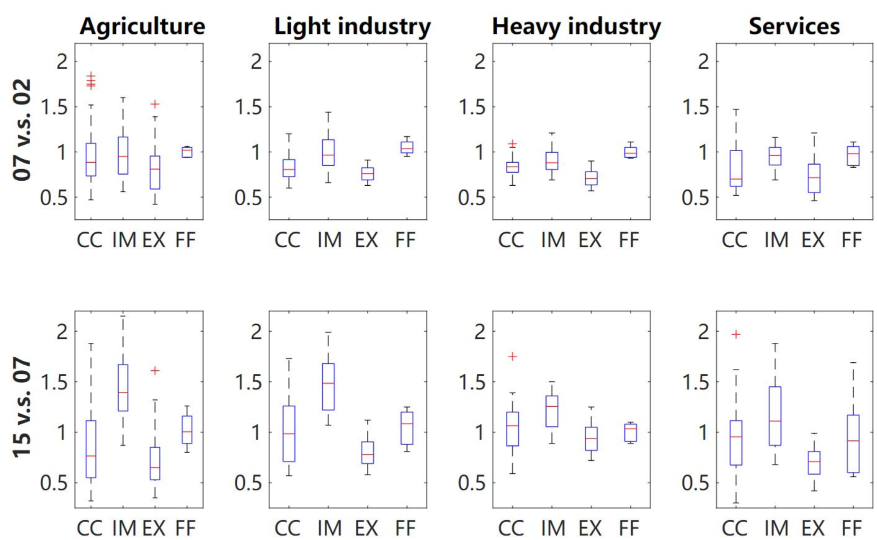
Note: Trade cost change are weighted by sectoral trade flow.

Figure A.6
Calibration Results: Trade Cost Change - 2007 v.s. 2002



Note: Trade cost change are weighted by sectoral trade flow

Figure A.7
Calibration Results: Trade Cost Change - 2015 v.s. 2007



Note: Trade cost change are weighted by sectoral trade flow

Figure A.8
Calibration Results: Trade Cost Change

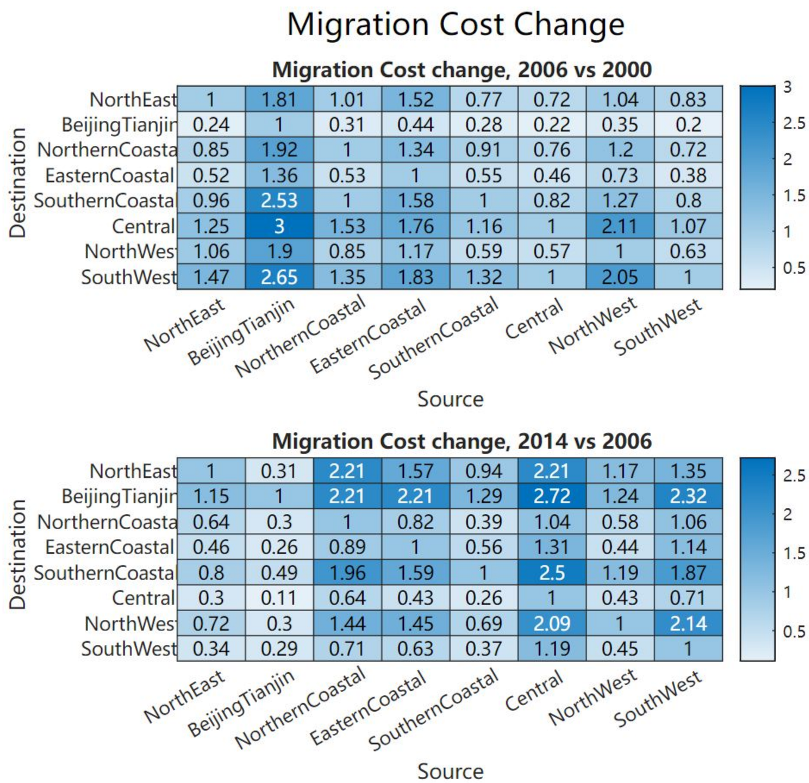


FIGURE A.9

CALIBRATION RESULTS: MIGRATION FRICTIONS CHANGE

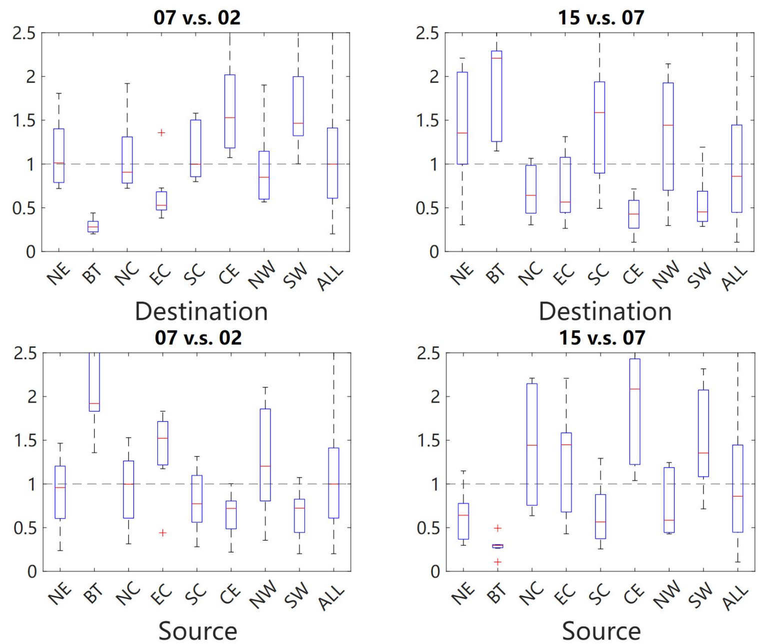


Figure A.10
Calibration Results: Migration frictions Change

TABLE A.1
Input-Output linkage coefficients of China's regions

Input-Output linkages	*Source sector*							
	Agricultural	*Light*	*Heavy*	*Services*	*Agricultural*	*Light*	*Heavy*	*Services*
Destination sector	*NorthEast*				*BeijingTianjin*			
Agricultural	0.18	0.28	0.01	0.01	0.21	0.13	0.00	0.01
Light	0.14	0.26	0.01	0.05	0.10	0.36	0.01	0.04
Heavy	0.12	0.11	0.56	0.25	0.18	0.14	0.62	0.22
Services	0.06	0.09	0.12	0.21	0.10	0.12	0.14	0.29
	NorthernCoastal				*EasternCoastal*			
Agricultural	0.18	0.23	0.01	0.01	0.14	0.12	0.01	0.01
Light	0.11	0.35	0.04	0.05	0.13	0.39	0.03	0.04
Heavy	0.14	0.11	0.59	0.24	0.13	0.16	0.63	0.24
Services	0.04	0.08	0.11	0.20	0.07	0.10	0.11	0.25
	SouthernCoastal				*Central*			
Agricultural	0.15	0.13	0.01	0.01	0.20	0.26	0.01	0.01
Light	0.12	0.38	0.03	0.05	0.10	0.31	0.03	0.05
Heavy	0.10	0.14	0.62	0.19	0.10	0.09	0.53	0.23
Services	0.07	0.10	0.13	0.24	0.05	0.09	0.14	0.22
	NorthWest				*SouthWest*			
Agricultural	0.19	0.31	0.01	0.01	0.20	0.25	0.01	0.01
Light	0.08	0.22	0.01	0.04	0.09	0.20	0.02	0.05
Heavy	0.12	0.08	0.49	0.25	0.09	0.11	0.54	0.26
Services	0.07	0.09	0.13	0.21	0.04	0.10	0.15	0.22
Destination sector	*China*				-			
Agricultural	0.16	0.09	0.11	0.07	-	-	-	-
Light	0.20	0.30	0.10	0.11	-	-	-	-
Heavy	0.01	0.03	0.51	0.12	-	-	-	-
Services	0.02	0.05	0.22	0.21	-	-	-	-

Notes: Roundabout input-output linkages for China's regions and the average column are calculated from take average directly from input-output linkage coefficients of all China's regions.

Appendix B: Algebra

B.1. Deriving labor flow function

Deriving Equation 12:

The C.D.F of utility for people from location m choose location n:

$$\begin{aligned} F(u)^{n,m} &= \Pr\left(V(\omega)^{n,m} \le u\right) \\ &= \Pr\left(\frac{z_n(\omega) W_n}{\nu^{n,m}} \le u\right) \\ &= \Pr\left(z_n(\omega) \le u \frac{\nu^{n,m}}{W_n}\right) \\ &= exp\left\{ -(u)^{-\kappa} (\frac{W_n}{\nu^{n,m}})^{\kappa} \right\} \end{aligned}$$

where $dF\left(u\right)^{n,m} = exp\left\{-(u)^{-\kappa}(\frac{W_n}{\nu^{n,m}})^{\kappa}\right\}(\frac{W_n}{\nu^{n,m}})^{\kappa}d(-(u)^{-\kappa})$.

The C.D.F of utility for people from location m:

$$\begin{aligned} F\left(u\right)^{m} &= \Pr\left(max_{n'}V\left(\omega\right)^{n',m} \leq u\right) \\ &= \prod_{n'=1}^{N_0} \Pr\left(z_{n'}\left(\omega\right) \leq u\frac{\nu^{n',m}}{W_{n'}}\right) \\ &= \prod_{n'=1}^{N_0} exp\left\{-\left(u\right)^{-\kappa}\left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\} \\ &= exp\left\{-\left(u\right)^{-\kappa}\sum_{n'=1}^{N_0}\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\} \\ &= exp\left\{-(u)^{-\kappa}\Psi_m\right\} \end{aligned}$$

where $\Psi_m \equiv \sum_{n'=1}^{N_0}(\frac{W_{n'}}{\nu^{n',m}})^{\kappa}$.

Let $m^{n,m}$ denote the fraction of workers originally in region m who migrated to region n, where $\sum_{n} m^{n,m} = 1$. From law of large numbers, I can derive

$$
\begin{aligned}
m^{n,m} &= \Pr\left(V\left(\omega\right)^{n,m} \geq max_{n'\neq n} V\left(\omega\right)^{n',m}\right) \\
&= \int_0^{+\infty} \Pr\left(max_{n'\neq n} V\left(\omega\right)^{n',m} \leq u\right) dF\left(u\right)^{n,m} \\
&= \int_0^{+\infty} exp\left\{-\left(u\right)^{-\kappa} \sum_{n'\neq n} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\} dF\left(u\right)^{n,m} \\
&= \int_0^{+\infty} \frac{exp\left\{-(u)^{-\kappa} \sum_{n'=1}^{N_0} (\frac{W_{n'}}{\nu^{n',m}})^{\kappa}\right\}}{exp\left\{-(u)^{-\kappa} (\frac{W_n}{\nu^{n,m}})^{\kappa}\right\}} dF\left(u\right)^{n,m} \\
&= \int_0^{+\infty} \frac{exp\left\{-\left(u\right)^{-\kappa} \sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\}}{exp\left\{-\left(u\right)^{-\kappa} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\}} exp\left\{-\left(u\right)^{-\kappa} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} d\left(-\left(u\right)^{-\kappa}\right) \\
&= \int_0^{+\infty} exp\left\{-\left(u\right)^{-\kappa} \sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} d\left(-\left(u\right)^{-\kappa}\right) \\
&= \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} \int_0^{+\infty} exp\left\{-\left(u\right)^{-\kappa} \Psi_m\right\} d\left(-\left(u\right)^{-\kappa}\right) \\
&= (\frac{W_n}{\nu^{n,m}})^{\kappa} \int_{-\infty}^{0} exp\left\{t\ \Psi_m\right\} dt \\
&= \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\Psi_m} = \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}}
\end{aligned}
$$

B.2. Trade Share of GDP under free trade, one sector economy

TABLE B.1
EQUILIBRIUM CONDITIONS ONE SECTOR MODEL

(FF1)	$c_n = \Upsilon w_n^{\beta} P_n^{(1-\beta)};\ \Upsilon \equiv (1-\beta)^{-(1-\beta)}\,\beta^{-\beta}$	$\forall n$
(FF2)	$P_n = A\left(\sum_{i=1}^{N} \lambda_i \left(\kappa_{ni} c_i\right)^{-\theta}\right)^{-1/\theta};\ A = \Gamma\left(\frac{1+\theta-\sigma}{\theta}\right)^{\frac{1}{(1-\sigma)}}$	$\forall n$
(FF3)	$\pi_{ni} = \frac{\lambda_i \left(c_i \kappa_{ni}\right)^{-\theta}}{\sum_{m=1}^{N} \lambda_m \left(c_m \kappa_{nm}\right)^{-\theta}} = \lambda_i \left(A\frac{c_i \kappa_{ni}}{P_n}\right)^{-\theta}$	$\forall n$
(HH1)	$W_n \equiv \frac{I_n}{P_n L_n};\ w_n L_n + D_n = I_n$	$\forall n$
(HH2)	$m^{n,m} = \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N0}\left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}}$	$\forall (n,m)$
(HH3)	$L_n = \sum_{m}^{N0} m^{n,m} \bar{L}_m$	$\forall n$
(MM1)	$X_n = (w_n L_n + D_n) + (1-\beta)\left(\sum_{i=1}^{N} \pi_{in} X_i\right) = \frac{w_n L_n}{\beta} + D_n$	$\forall n$
(MM2)	$\sum_{i=1}^{N} \pi_{in} X_i = \sum_{i=1}^{N} \pi_{ni} X_n - D_n$	$\forall n$
(MM2′)	$w_n L_n = \beta\left(\sum_{i=1}^{N} \pi_{in} X_i\right)$	$\forall n$

Notes : $\pi_{nn} = \lambda_n \left(A\frac{c_n}{P_n}\right)^{-\theta} = \lambda_n \left(A\frac{\Upsilon {w_n}^{\beta} {P_n}^{(1-\beta)}}{P_n}\right)^{-\theta} = (A\Upsilon)^{-\theta} \lambda_n \left(\frac{w_n}{P_n}\right)^{-\beta\theta}.$

In the one-sector economy, under free trade, prices are equalized across countries.

$$P = P_n = A\left[\sum_{i=1}^{N} \lambda_i \left(\Upsilon {w_i}^{\beta} {P_i}^{(1-\beta)}\right)^{-\theta}\right]^{-1/\theta} = (A\Upsilon)^{1/\beta}\left[\sum_{i=1}^{N} \lambda_i \left(w_i\right)^{-\theta\beta}\right]^{-1/\theta\beta} \tag{B.1}$$

From FF3, we have

$$\begin{aligned}\pi_{ni} &= (A\Upsilon)^{-\theta}\,\lambda_i\left(\frac{w_i}{P_i}\right)^{-\beta\theta} \\ &= (A\Upsilon)^{-\theta}\,\lambda_i\,(w_i)^{-\beta\theta}\,(P_i)^{\beta\theta} \\ &= (A\Upsilon)^{-\theta}\,\lambda_i\,(w_i)^{-\beta\theta}\left((A\Upsilon)^{1/\beta}\left[\sum_{i=1}^{N}\lambda_i\,(w_i)^{-\theta\beta}\right]^{-1/\theta\beta}\right)^{\beta\theta} \\ &= \lambda_i\,(w_i)^{-\beta\theta}\left(\left[\sum_{i=1}^{N}\lambda_i\,(w_i)^{-\theta\beta}\right]^{-1}\right)\end{aligned} \tag{B.2}$$

From MM1 and MM2, we obtain:

$$\sum_{i=1}^{N}\pi_{in}w_iL_i = w_nL_n \tag{B.3}$$

So

$$\sum_{i=1}^{N}\frac{w_iL_i}{\left[\sum_{m=1}^{N}\lambda_m\,(w_m)^{-\theta\beta}\right]}\lambda_n\,(w_n)^{-\beta\theta} = w_nL_n \tag{B.4}$$

$$w_n = \left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}\left(\sum_{i=1}^{N}\frac{w_iL_i}{\left[\sum_{m=1}^{N}\lambda_m\,(w_m)^{-\theta\beta}\right]}\right)^{\frac{1}{1+\beta\theta}} = \left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}V \tag{B.5}$$

where $V = \left(\sum_{i=1}^{N}\frac{w_iL_i}{\left[\sum_{m=1}^{N}\lambda_m\,(w_m)^{-\theta\beta}\right]}\right)^{\frac{1}{1+\beta\theta}}$

Define Z_n as productive capacity of the economy $Z_n \equiv \lambda_n {L_n}^{\theta\beta}$, From Equation B.1 and Equation B.5:

$$\begin{aligned}\frac{w_n}{P_n} &= \left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}V(A\Upsilon)^{-1/\beta}\left[\sum_{i=1}^{N}\lambda_i\left(\left(\frac{\lambda_i}{L_i}\right)^{\frac{1}{1+\beta\theta}}V\right)^{-\theta\beta}\right]^{1/\theta\beta} \\ &= {L_n}^{-1}\left(\lambda_n{L_n}^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}(A\Upsilon)^{-1/\beta}\left[\sum_{i=1}^{N}\left(\lambda_i{L_i}^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}\right]^{1/\theta\beta} \\ &= (A\Upsilon)^{-1/\beta}\,{L_n}^{-1}\,(Z_n)^{\frac{1}{1+\beta\theta}}\left[\sum_{i=1}^{N}(Z_i)^{\frac{1}{1+\beta\theta}}\right]^{1/\theta\beta}\end{aligned} \tag{B.6}$$

From FF3,

$$\pi_{ni} = (A\Upsilon)^{-\theta} \lambda_i \left(\frac{w_i}{P_i}\right)^{-\beta\theta} = (Z_i)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{-1} \tag{B.7}$$

Now, I derive China's Trade share of GDP, where $n \in \mathbb{N}_0$ are regions within China, $n \in \mathbb{N}_1$ are foreign regions.

$$\begin{aligned}
\text{TradeShare}_{CHN} &= \frac{\sum_{n\in\mathbb{N}_0} X_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right)}{\sum_{n\in\mathbb{N}_0} \beta X_n} \\
&= \sum_{n\in\mathbb{N}_0} \frac{\beta X_n}{\sum_{n\in\mathbb{N}_0} \beta X_n} \frac{X_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right)}{\beta X_n} \\
&= \frac{1}{\beta} \sum_{n\in\mathbb{N}_0} \psi_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right)
\end{aligned} \tag{B.8}$$

where ψ_n is defied as the region n's GDP share of China's GDP.

From MM2, we have $\sum_{i=1}^{N} \pi_{in} w_i L_i = w_n L_n$; From Equation B.7, we have $\pi_{in} = (Z_n)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{-1}$. So:

$$\psi_n = \frac{(Z_n)^{\frac{1}{1+\beta\theta}}}{\sum_{n\in\mathbb{N}_0} (Z_n)^{\frac{1}{1+\beta\theta}}} \tag{B.9}$$

Then,

$$\text{TradeShare}_{CHN} = \frac{1}{\beta} \sum_{n\in\mathbb{N}_0} \psi_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta} \sum_{n\in\mathbb{N}_0} \frac{(Z_n)^{\frac{1}{1+\beta\theta}}}{\sum_{n\in\mathbb{N}_0} (Z_n)^{\frac{1}{1+\beta\theta}}} \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta} \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) \tag{B.10}$$

From Equation B.7 and HH2,

$$\frac{w_n}{P_n} = (A\Upsilon)^{-\frac{1}{\beta}} L_n{}^{-1} (Z_n)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{\frac{1}{\theta\beta}} = (A\Upsilon)^{-\frac{1}{\beta}} L_n{}^{-1} (Z_n)^{\frac{1}{1+\beta\theta}} \Lambda \tag{B.11}$$

where $\Lambda \equiv \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{\frac{1}{\theta\beta}}$.

$$L_n = \sum_{m}^{N_0} \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}} \bar{L}_m = \sum_{m}^{N_0} \frac{\left(\frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N_0} \left(\frac{\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{1}{1+\beta\theta}}}{\nu^{n',m}}\right)^{\kappa}} \bar{L}_m \tag{B.12}$$

Case 1: Friction-less labor flow $\forall n, m \in \mathbb{N}_0$ and $n \neq m$, $\nu^{n,m} = 1$.

$$\frac{L_n}{\sum_m^{N_0} \bar{L}_m} = \frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'}^{N_0} \left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}} \tag{B.13}$$

So

$$\frac{\lambda_n}{\lambda_m} = \left(\frac{L_n}{L_m}\right)^{\frac{1+\beta\theta+\kappa}{\kappa}} \tag{B.14}$$

$$L_n = \frac{(\lambda_n)^{\frac{\kappa}{1+\kappa+\beta\theta}}}{\sum_{n'}^{N_0} (\lambda_{n'})^{\frac{\kappa}{1+\kappa+\beta\theta}}} \sum_m^{N_0} \bar{L}_m \tag{B.15}$$

So

$$\begin{aligned} TradeShare_{CHN} &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \pi_{ni}\right) \\ &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \frac{\left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}{\sum_{i\in\mathbb{N}_0} (\lambda_i)^{\frac{1+\kappa}{1+\kappa+\beta\theta}} + \sum_{i\in\mathbb{N}_1} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \\ &= \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \frac{(\lambda_i)^{\frac{1+\kappa}{1+\kappa+\beta\theta}}}{\sum_{i\in\mathbb{N}_0} (\lambda_i)^{\frac{1+\kappa}{1+\kappa+\beta\theta}} + \sum_{i\in\mathbb{N}_1} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \end{aligned} \tag{B.16}$$

Case 2: Labor flow with maximum friction $\forall n, m \in \mathbb{N}_0$ and $n \neq m$, $\nu^{n,m} = \infty$.

$$L_n = \bar{L}_m \tag{B.17}$$

So

$$\begin{aligned} TradeShare_{CHN} &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \pi_{ni}\right) \\ &= \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}_1} \frac{\left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}{\sum_{i\in\mathbb{N}} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \\ &= \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}_0} \frac{\left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}{\sum_{i\in\mathbb{N}} \left(\lambda_i \left(\bar{L}_i\right)^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}}\right) \end{aligned} \tag{B.18}$$

Appendix C: Algorithm and Equilibrium Conditions

Table C.1 lists the entire set of equilibrium conditions in our model, and algorithm 1 describes the methodology to compute the equilibrium.

TABLE C.1
Equilibrium conditions

(F1)	$c_n^j = \Upsilon_n^j w_n^{\gamma_n^j} \prod_{k=1}^{J} P_n^{k\,\gamma_n^{k,j}}$; $\Upsilon_n^j \equiv \prod_{k=1}^{J} \gamma_n^{k,j\,-\gamma_n^{k,j}} \gamma_n^{j\,-\gamma_n^j}$	$\forall(n,j)$
(F2)	$P_n^j = A^j\Big(\sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta}\Big)^{-\frac{1}{\theta}}$; $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{(1-\sigma^j)}}$	$\forall(n,j)$
(F3)	$\pi_{ni}^j = \frac{\lambda_i^j \left(c_i^j \kappa_{ni}^j\right)^{-\theta}}{\sum_{m=1}^{N} \lambda_m^j \left(c_m^j \kappa_{nm}^j\right)^{-\theta}} = \lambda_i^j \left(A^j \frac{c_i^j \kappa_{ni}^j}{P_n^j}\right)^{-\theta}$	$\forall(n,j)$
(H1)	$P_{n=} \prod_{j=1}^{J} \left(\frac{P_n^j}{\alpha_n^j}\right)^{\alpha_n^j}$	$\forall(n)$
(H2)	$W_n \equiv \frac{I_n}{P_n L_n}$; $w_n L_n + D_n = I_n$	$\forall(n)$
(H3)	$m^{n,m} = \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}}$	$\forall(n,m)$
(H4)	$L_n = \sum_{m}^{N0} m^{n,m} \bar{L}_m$	$\forall(n)$
(M1)	$X_n^j = \alpha_n^j I_n + \sum_{k=1}^{J} \gamma_n^{j,k} \left(\sum_{i=1}^{N} X_{in}^k\right)$	$\forall(n,j)$
(M2)	$\sum_{j=1}^{J} \sum_{i=1}^{N} X_{ni}^j - D_n = \sum_{j=1}^{J} \sum_{i=1}^{N} X_{in}^j$	$\forall(n,j)$
(M2′)	$w_n L_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j$	$\forall(n)$

Algorithm 1 Algorithm to Solve the model

1: Guess GDP_n^0 or ${(wL)_n}^0$.
2: Solve for w_{n0} which make F1 F2 H1 H2 H3 H4 holds. ($fslove$ package in matlab to solve the systems of equations to match fixed GDP_n^0 or ${(wL)_n}^0$, such that ${(wL)_n}^{\mathbf{0}} = {w_n}^{\mathbf{0}} L_n^{\mathbf{0}}({w_n}^{\mathbf{0}})$.) .
3: Guess $P^k_{n\,0}$. From F1 F2 generate $P^k_{n\,1}$, then iterate until $P^k_{n\,0}$ convergence.
4: Given w_{n0} $P^k_{n\,0}$, From F3, calculate π^j_{ni0}.
5: Guess L_{n0}. From $P^k_{n\,0}$, H1, H2, H3, H4, generate L_{n1}, then iterate until L_{n0} convergence.
6: From w_{n0}, L_{n1}, $P^k_{n\,1}$, H2, M1, generate X^j_{n0}, then calculate the market clear condition M2 or M2$'$.
7: If M2 or M2$'$ not holds, Update new guess GDP_n^1 or ${(wL)_n}^1$, repeat from step 2 to step 6 until GDP_n^0 or ${(wL)_n}^0$ holds.

Update new guess GDP_n^1 or ${(wL)_n}^1$ using similar way from Alvarez and Lucas Jr (2007):

$$Z_n\left({(wL)_n}^{\mathbf{0}}\right) \equiv \left[\sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi^j_{in} X_i^j - {(wL)_n}^{\mathbf{0}}\right]$$

$${(wL)_n}^{\mathbf{1}} \equiv T\left({(wL)_n}^{\mathbf{0}}\right) = {(wL)_n}^{\mathbf{0}}\left(1 + v\frac{Z_n\left({(wL)_n}^{\mathbf{0}}\right)}{{(wL)_n}^{\mathbf{0}}}\right) = {wL_n}^{\mathbf{0}} + vZ_n\left({(wL)_n}^{\mathbf{0}}\right) \tag{C.1}$$

such that world GDP always equal to a constant. $v = 0.5$ controls convergence speed.

$$\sum_{n=1}^{N} {(wL)_n}^{\mathbf{1}} = \sum_{n=1}^{N} {(wL)_n}^{\mathbf{0}} = constant \tag{C.2}$$

$$\begin{aligned}
\sum_{n=1}^{N} {(wL)_n}^{\mathbf{1}} &= \sum_{n=1}^{N} T({(wL)_n}^{\mathbf{0}}) \\
&= \sum_{n=1}^{N} {(wL)_n}^{\mathbf{0}} + \sum_{n=1}^{N} vZ_n\left({(wL)_n}^{\mathbf{0}}\right) \\
&= \sum_{n=1}^{N} {(wL)_n}^{\mathbf{0}} + \sum_{n=1}^{N} v\left[\sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi^j_{in} X_i^j - {(wL)_n}^{\mathbf{0}}\right] \\
&= \sum_{n=1}^{N} {(wL)_n}^{\mathbf{0}} \\
&= constant
\end{aligned}$$

Appendix D: Data

The data used in this paper are from: the 5th National Census Data in 2000, the 6th National Census Data in 2005, the 7th National Census Data in 2015; Penn World Table (PWT) 10.0 (2002, 2007, 2015) (Feenstra, Inklaar and Timmer, 2015); The World Input-Output Database (WIOD) (2002, 2007) (Timmer et al., 2015); OECD Inter-Country Input-Output (ICIO) Tables (2015) (OECD, 2021); The China Cross Regional Input-Output Table (2002, 2007, 2015) (Zhang and Qi, 2012; Zheng et al., 2020); Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) (Head and Mayer, 2014).

D.1. Concordance for the data from different sources

I merge the data from different sources into 4 sectors and 8 regions. This section shows how I combine the data together. The unified input-output table are 4 sectors, 23 regions (8 China regions and 14 foreign economics plus a ROW), I then collapse this table to 4 sector 11 regions version (8 China regions and 2 foreign economics plus a ROW) for the purpose of quantitative analysis.

Sectors Classification

The sector classification of WIOD tables or OECD IRIO Table are from International Stan-

TABLE D.1
Sector Classification

4 sectors	*WIOD Table or OECD IRIO Table, ISIC rev4*	*China IO Table, GB/T 4754-2011*
A. Agriculture	*(A)Agriculture, forestry and fishing*	*(A)Agriculture, forestry and fishing*
B. Light industry	*(C10-18) Manufacturing*	*(C13-24)manufacturing*
C. Heavy industry	*B)Mining and quarrying;* *(C19-C33)Manufacturing;* *(D35)Electricity, gas, steam and air conditioning supply;* *(E36-39) Water supply, sewerage, waste management and remediation activities*	*(B)The mining industry;* *(C25-43)manufacturing;* *(D)Electricity, heat, gas and water production and supply industry*
D. Services	*(F-S)Remaining sectors from F to S*	*(E-T)Remaining sectors from E to T*

dard Industrial Classification of All Economic Activities, Revision 4. The sector classification of China cross region IO table and individual province Io Table are from China's Industry classification for national economic activities, GB/T 4754-2.

China Regions

TABLE D.2
China Regions

8 Regions	*31 Provinces*
A. Northeast	*1.Heilongjiang, 2.Jilin, 3.Liaoning*
B. Beijing and Tianjin	*4.Beijing, 5.Tianjin*
C. Northern Coastal	*6.Hebei, 7.Shandong*
D. Eastern Coastal	*8.Jiangsu, 9.Shanghai, 10.Zhejiang*
E. Southern Coastal	*11.Fujian, 12.Guangdong, 13.Hainan*
F. Central	*14.Shanxi, 15.Henan, 16.Anhui, 17.Hubei, 18.Hunan, 19.Jiangxi*
G. Northwest	*20.Inner Mongolia, 21.Shaanxi, 22.Ningxia, 23.Gansu, 24.Qinghai, 25. Xinjiang*
H. Southwest	*26.Sichuan, 27.Chongqing, 28.Guangxi, 29.Yunnan, 30.Guizhou, 31Tibet*

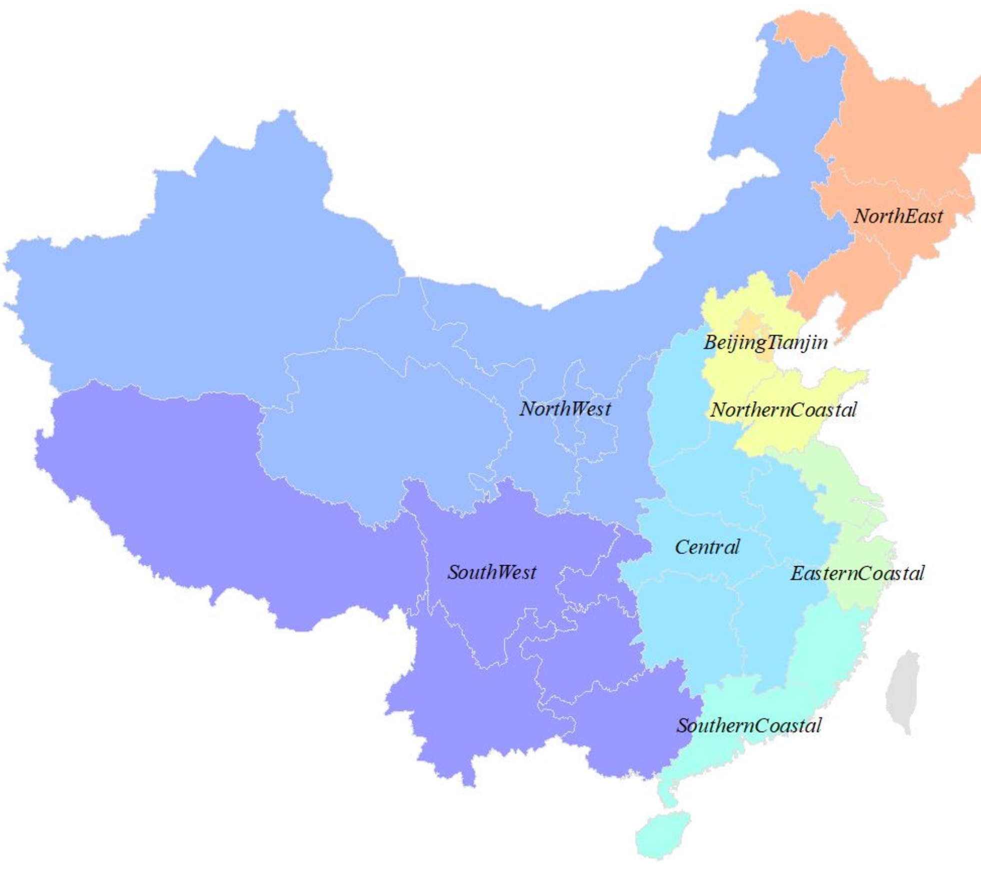


Figure D.1
China Regions

Foreign Regions

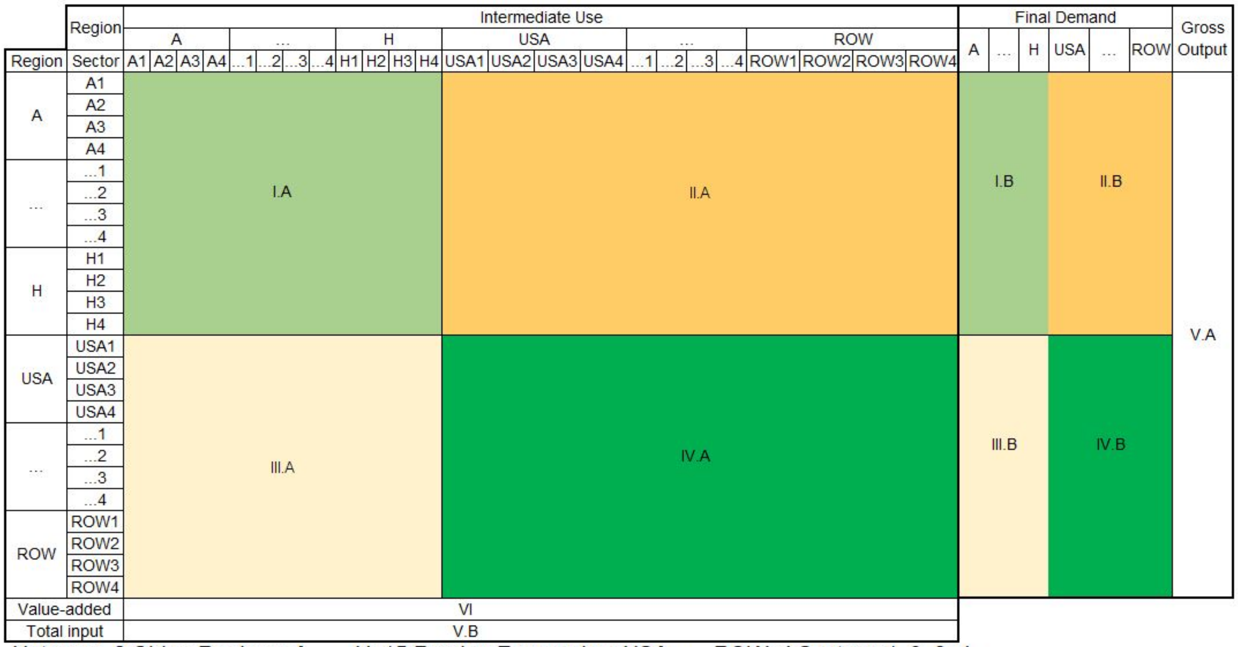
TABLE D.3
FOREIGN REGIONS

3 Foreign regions	*15 Foreign regions*
G7-JPN	*Canada, Germany, France, United Kingdom, Italy, United States*
Asian3	*Japan, Korea, Taiwan Region*
ROW	*Australia, India, Brazil, Russia, Switzerland*
	ROW

D.2. Labor Migration Share and Country Level Total Employment

The China's labor flow data are from the 5th, 6th and 8th national Census (2000, 2002, 2015). The national Census datasets excluding people in active military service and reports peoples *hukou* registration province and living province in the survey year. I calculate the population flow share for the year 2000, 2005, 2015. Since there is no population flow data at the year 2002 and 2007 as far as I know, I use the population flow share of the year 2000 and 2005 as an approximation for the year 2002 and 2007. The country level total labor force data are from the PWT 10.0. This dataset reports the number of person engaged (in millions) at year and country level.

D.3. The Unified Inter-Region Input-Output (IRIO) Table



Note: e.g. 8 China Regions: A , ..., H; 15 Foreign Economies: USA, ..., ROW; 4 Sectors: 1, 2, 3, 4.

Figure D.2
An example for 23-Region and 4-Sector Inter-Region Input-Output table

This section explains how I constructed The Unified Inter-Region Input-Output (IRIO) Table, which embodies industry-level bilateral trade flows. The unified input-output table comprises 4 sectors and 23 regions (8 China regions, 14 foreign economies, and an aggregate of the rest of the world (ROW)). I then collapsed this table to a 4-sector, 11-regions version for the purpose of quantitative analysis. I built the unified Inter-Region Input-Output (IRIO) Table based on the World IO Table and China IO table. Figure D.2 presents a schematic IRIO Table with 8 China regions (A, ..., H), 15 foreign regions (USA, ..., ROW), and 4 sectors (1 for agriculture, 2 for light industry, 3 for heavy industry, 4 for services). The colored areas in the table represent the industry-level bilateral trade flows in intermediate and final goods, where each row corresponds to a source region-sector, and each column corresponds to a destination region-sector. The last column represents the gross output for each region's particular sector. The bottom two rows represent the value-added and total input for each region's particular sector. All the values are recorded at current prices, denoted in millions of dollars.

World IO Table

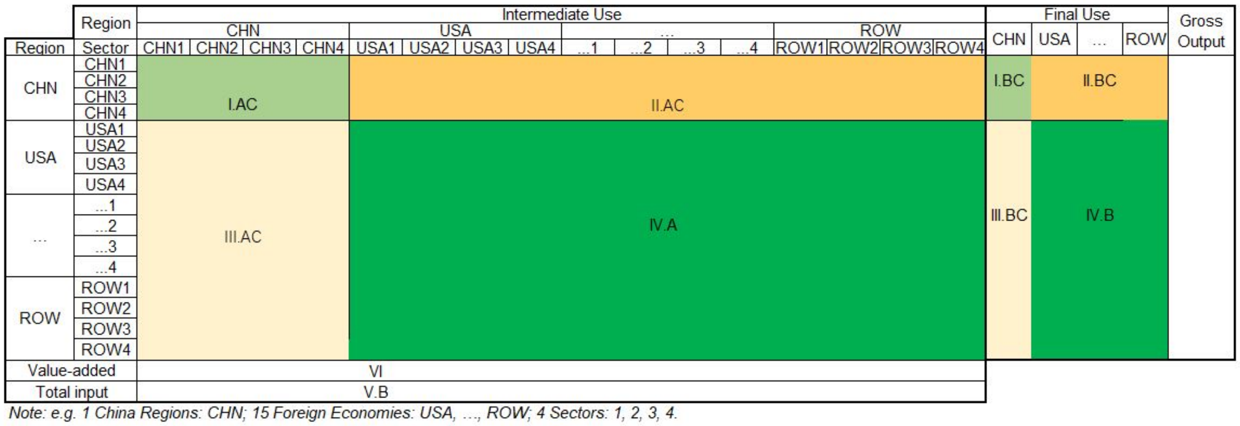


Figure D.3
An example for 16-Region and 4-Sector World IO table

In Figure D.2 and Figure D.3, the dark green area represents the industry-level bilateral trade flows in intermediate and final goods between foreign regions. To obtain this data, I first collapsed the World IO table from three different years: 2002 and 2007 from the WIOD dataset, and 2015 from the OECD dataset. I collapsed these tables into 4 sectors and 15 economies plus a ROW. The data in the dark blue area is derived from the collapsed World IO tables. The World IO tables are recorded at current prices, denoted in millions of dollars. Only the data for the years 2002, 2007, and 2015 is used.

China IO Table

	Region	Intermediate Use												Final Demand			EX	STK	ERR OR	Gross Output
		A				...				H				A	...	H				
Region	Sector	A1	A2	A3	A4	...1	...2	...3	...4	H1	H2	H3	H4							
A	A1																			
	A2																			
	A3																			
	A4																			
...	...1																			
	...2				I.A									I.B			EX			GO
	...3																			
	...4																			
H	H1																			
	H2																			
	H3																			
	H4																			
IM									IM											
Value-added					VA															
Total input					GI															

Note: e.g. 8 China Regions: A , ..., H; Sectors: 1, 2, 3, 4.

Figure D.4
An example for 8-Region and 4-Sector China IO table

In Figure D.2 and Figure D.4, the light green area embodies the industry-level bilateral trade flows in intermediate and final goods between China's regions. This data is obtained from China IO tables. I firstly collapse the China IO tables into 8 regions, 4 sectors. For each year, I then merge the 16 regions, 4 sectors World IO table to the 8 regions, 4 sectors China IO table to get The Unified Inter-Region Input-Output (IRIO) Table. The detailed steps are list in the following part.

Merge World IO Table to the China IO Table

Basing on the ratio from the collapsed China IO table, I then scale industry-level bilateral trade flows in intermediate and final goods from collapsed China IO table.

Step 1: Scale China's IO table with the ratio of China's GDP in the World IO table to its GDP in the China IO table. Since China IO table are recorded at current prices, denoted in ten thousand of yuan, So I scale every value in the China IO table with the ratio of China's GDP in the World IO table to its GDP in the China IO table.

$$ChinaIO_{after\ scale} = ChinaIO_{before\ scale} \cdot \frac{China\ GDP\ in\ World\ IO}{China\ GDP\ in\ China\ IO}$$

Thus, the scaled China IO table now is recorded at current prices, denoted in millions of dollars.

Step 2: Scale sectoral GDP and sectoral total input in the China IO table.
Scale the sectoral GDP in the China IO table such that, for each sector, the aggregate GDP

across China's regions equals exactly the same value as China's sectoral GDP in the World IO table. For sector $j \in \{1,2,3,4\}$ and $n \in \{A,B,...,H\}$, scale GDP of region n sector j in the China IO table through

$$GDP^{nj}{}_{after\ scale} = GDP^{CHNj}_{World\ IO} \cdot \frac{GDP^{nj}_{China\ IO}}{\sum_n^{\{A,...,H\}} GDP^{nj}_{China\ IO}}$$

Similarly, Scale the sectoral total input in the China IO table such that, for each sector, the aggregate GDP across China's regions equals exactly the same value as China's sectoral GDP in the World IO table. For sector $j \in \{1,2,3,4\}$ and $n \in \{A,B,...,H\}$, scale total input of region n sector j in the China IO table through

$$Total.input^{nj}{}_{after\ scale} = Total.input^{CHNj}_{World\ IO} \cdot \frac{Total.input^{nj}_{China\ IO}}{\sum_n^{\{A,...,H\}} Total.input^{nj}_{China\ IO}}$$

Then, from the scaled sectoral GDP and sectoral total input, calculate share of labor inputs for each China's region and sector (n,j):

$$gama_{nj,t} = \frac{GDP^{nj,t}_{after\ scale}}{Total.input^{nj,t}_{after\ scale}}$$

$$AVE.gama_{nj} = \frac{\sum_{t=2002,2007,2015} gama_{nj,t}}{3}$$

It has been observed that the calculated labor input shares for specific sectors and regions in China vary significantly across different years, while the labor input shares for the aggregate of China and other countries, as derived from the world IO table, have remained relatively stable. This variation may be attributed to the questionable quality of the total sectoral inputs data in the China IO table. Moreover, when conducting counterfactual analyses, it is customary to assume that production shares remain unchanged. Additionally, in comparison to the total input (or total output) data, GDP data is easier to obtain and is associated with fewer statistical errors for each sector. Therefore, to address this issue, an average of labor shares across years is taken for each of China's regions and sectors. The averaged labor shares, along with the sectoral GDP data, are then used to impute the sectoral total inputs:

$$Total.input^{nj}_{after\ scale\ and\ correct\ error} = \frac{GDP^{nj}_{after\ scale}}{AVE.gama_{nj}} \tag{D.1}$$

Finally, I compare the sectoral total input of aggregate China calculated from Equation D.1 to the corresponding value from the World IO table, and it shows that there only few change. Thus, Equation D.1 effectively reallocates sectoral inputs across China's regions without significantly altering the aggregate sectoral inputs. At the same time, it successfully addresses the issue of high variation in labor shares across years.

Step 3: Scale sectoral imports and exports in the China IO table.

In Figure D.4, the sectoral imports of China's regions are represented in part $A.IM$, and the sectoral exports of China's regions are represented in part $B.EX$. Scale sectoral imports or exports in the China IO table such that, for each sector, the aggregate import or export across China's regions equals exactly the same value as the total China's sectoral imports or exports in the World IO table. For sector $j \in \{1, 2, 3, 4\}$ and $n \in \{A, B, ..., H\}$, scale imports or exports of region n sector j in the China IO table through

$$IM^{nj,intermediate}{}_{after\ scale} = IM^{CHNj,intermediate}_{World\ IO} \cdot \frac{IM^{nj,intermediate}_{China\ IO}}{\sum_n^{\{A,...,H\}} IM^{nj,intermediate}_{China\ IO}}$$

$$IM^{nj,final}{}_{after\ scale} = IM^{CHNj,final}_{World\ IO} \cdot \frac{IM^{nj,final}_{China\ IO}}{\sum_n^{\{A,...,H\}} IM^{nj,final}_{China\ IO}}$$

$$EX^{nj}{}_{after\ scale} = EX^{CHNj}_{World\ IO} \cdot \frac{EX^{nj}_{China\ IO}}{\sum_n^{\{A,...,H\}} EX^{nj}_{China\ IO}}$$

Where

$$IM^{CHNj,intermediate}_{World\ IO} \equiv \sum_{k=\{1,2,3,4\}} \sum_{m=\{foreign\ regions\}} INPUT.Intermediate^{mk,j}_{World\ IO}$$

$$IM^{CHNj,final}_{World\ IO} \equiv \sum_{k=\{1,2,3,4\}} \sum_{m=\{foreign\ regions\}} INPUT.Final^{mk,final}_{World\ IO}$$

$$\begin{aligned} EX^{CHNj}_{World\ IO} \equiv & \sum_{k=\{1,2,3,4\}} \sum_{m=\{foreign\ regions\}} OUTPUT^{mk,j}_{World\ IO,Intermediate\ part} \\ & + \sum_{k=\{1,2,3,4\}} \sum_{m=\{foreign\ regions\}} OUTPUT^{mk,j}_{World\ IO,Final\ part} \end{aligned}$$

As shown in the World Input-Output (IO) table Figure D.3, $INPUT.Intermediate^{mk,j}_{World\ IO}$ represents the inputs to China's sectoral production in sector j, originating from foreign region m and sector k (Part $III.AC$); $INPUT.Final^{mk,final}_{World\ IO}$ represents China's final goods usage, constructed by goods from foreign region m and sector k (Part $III.BC$); $OUTPUT^{mk,j}_{World\ IO,Intermediate\ part}$ represents the intermediate part of outputs of China's sectoral production in sector j, used by foreign region m and sector k (Part $II.AC$); $OUTPUT^{mk,j}_{World\ IO,Final\ part}$ represents the final part of outputs of China's sectoral production in sector j, used by foreign region m (Part $II.BC$).

Step 4: Scale inner trade across China's regions in the China IO table.

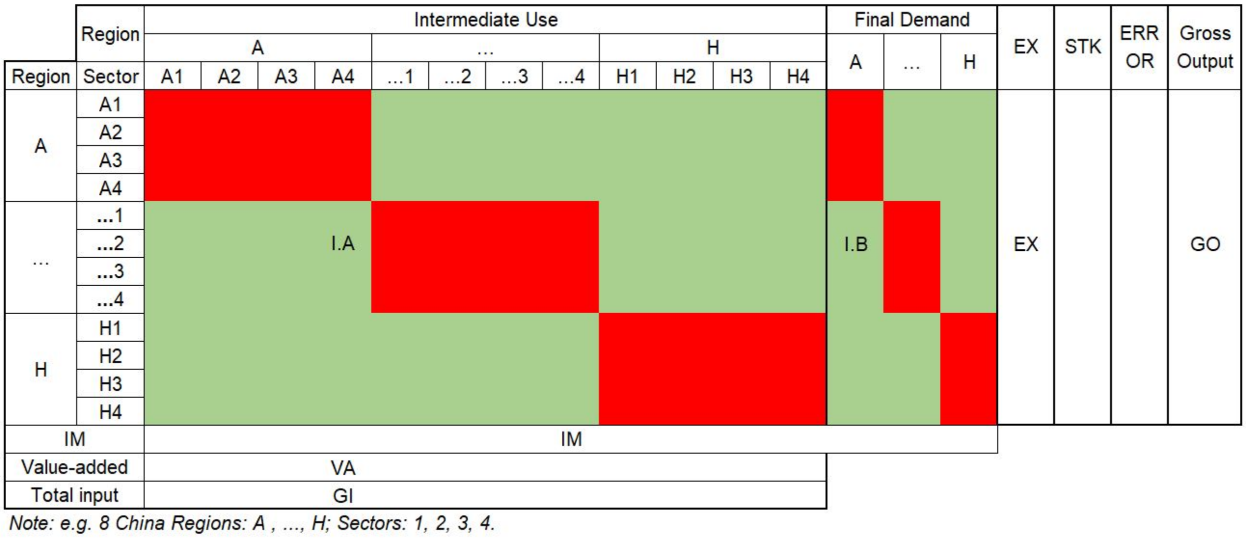


Figure D.5
Scale inner trade across China's regions in China IO table

In Figure D.5, the green area represents the industry-level bilateral trade flows in intermediate and final goods between two distinct regions within China. To ensure that The Unified Inter-Region Input-Output (IRIO) table inherits good properties in terms of China's sectoral within-country trade share of GDP, I scale the values in the blue area in a way that the sectoral within-country trade share of GDP equals the corresponding value calculated from the original China IO table:

$$China.IO^{mj,nk}_{green.area} = InnerFlow^{j} \cdot \frac{C.IO^{mj,nk}_{after\ scale}}{\sum_{k=\{1,2,3,4\}} \sum_{m,n=\{A,...,H\},m\neq n} C.IO^{mj,nk}_{after\ scale} + C.IO^{mj,n.final}_{after\ scale}}$$

$$China.IO^{mj,n.final}_{green.area} = InnerFlow^{j} \cdot \frac{C.IO^{mj,n.final}_{after\ scale}}{\sum_{k=\{1,2,3,4\}} \sum_{m,n=\{A,...,H\},m\neq n} C.IO^{mj,nk}_{after\ scale} + C.IO^{mj,n.final}_{after\ scale}}$$

$$InnerFlow^{j} = China.GDP_{afterscale} \cdot \frac{China.InnerTrade^{j,ChinaIO}_{beforescale}}{China.GDP^{China.IO}_{beforescale}}$$

In the context of the notation used: m represents the source region; j represents the source sector; n represents the destination region; k represents the destination sector. $China.IO^{mj,nk}$ or $C.IO^{mj,nk}$ represents the value of sector j output in region m, which is used as intermediate inputs in the production of goods in sector k and region n. $C.IO^{mj,nk}$ represents the value of sector j output in region m, which is used for final consumption by region n. $China.InnerTrade^{j,ChinaIO}$ denotes the values of inner trade, for sector j goods, across China's regions, which are calculated from the China IO table.

Meanwhile, in Figure D.5, the red area illustrates the intermediate usage of sectoral inputs and final consumption from China's own regions. We have scaled all areas of the China IO table except for the red area. Then, I firstly scale the intermediate part of the read area such that for each column, the sum of inputs across different regions and sectors equal to the value of last row (value total input).

for $\forall n \in \{A, ..., H\}$, $\forall k \in \{1, 2, 3, 4\}$

$$China.IO^{nj,nk}_{inter.\ red\ area} = China.IO^{n:,nk}_{inter.\ red\ area} \cdot \frac{China.IO^{nj,nk}_{before\ scale}}{\sum_{j=\{1,2,3,4\}}\{China.IO^{nj,nk}_{before\ scale}\}}$$

$$\begin{aligned} China.IO^{n:,nk}_{inter.\ red\ area} &= Total.input^{nk}_{after\ scale} - GDP^{nk}_{after\ scale} \\ &- \sum_{j=\{1,2,3,4\}} \sum_{m=\{A,...,H\},n\neq m} \{China.IO^{mj,nk}_{green\ area}\} \end{aligned}$$

The final part of the read area is used to balance the table, ensuring that the gross output (aggregation across columns for each row) equals the total input (aggregation across rows for each intermediate column).

$$Total.input^{nk}_{after.scale} = Gross.output^{nk}_{after.scale}$$

$$\begin{aligned} China.IO^{mj,m}_{final.\ red\ area} = Gross.output^{mj} &- \sum_{k=\{1,2,3,4\}} \sum_{n=\{A,...,H\}} China.IO^{mj,nk}_{inter,after\ sacle} \\ &- \sum_{n=\{A,...,H\},n\neq m} China.IO^{mj,n}_{final.after\ sacle} \end{aligned}$$

Here, $China.IO^{nj,nk}_{inter.\ red\ area}$ represents the sacled value of the sector j region n outputs used by region n sector k. $China.IO^{mj,m}_{final.\ red\ area}$ is the the sacled value of sector j region m outputs used as final consumption by region m, which is calculated based on the data from the scaled China IO table.

Noteworthy to say, for the year 2007, for some (m, j), the value of $China.IO^{mj,m}_{final.\ red\ area}$ I have backed out was negative, I resolve this issue by scaling all of the final parts ($China.IO^{mj,n}_{final}, \forall n \in \{n = A, ..., H\}$) instead of just scaling the $China.IO^{mj,m}_{final.\ red\ area}$. After this treatment, still one row (m, j) have negative values for the final consumptions, I then assume that final consumptions of this row equal were to zeros, and fix the distance between total input and gross outputs by adjusting the value added of this region-sector (m, j). The size of negative value of $China.IO^{mj,m}_{final.\ red\ area}$ or all of the final parts ($China.IO^{mj,n}_{final}, \forall n \in \{n = A, ..., H\}$) per se is small relevant to the total outputs. So, the treatment above only leads to a small change in the table, but it keeps the property of the IO table where total inputs are always equal to the gross output. Additionally, it maintains China's sectoral inner trade share of GDP, ensuring it does not deviate from the counterpart ratio calculated from the original China IO table (Even though this table also have larger error terms in each row). We can see from Table D.4 that, the unified IO table I have generated inherit good property in terms of the ratio of trade share of GDP from its source tables (China IO and World IO) and WDI dataset.

Step 5: Expand sectoral imports for specific China region in the China IO table. Actually, this step extend area IM in Figure D.4 to area $III.A$ and $III.B$ in Figure D.2. To ensure that The Unified Inter-Region Input-Output (IRIO) table inherits good properties in terms of China's sectoral imports between aggregate China and any foreign regions, I extend area IM in Figure D.4 in such a way that the aggregated sectoral import between China and any foreign regions equal exactly the same value from the original World IO table:
for $\forall n \in \{A, ..., H\}$, $\forall k \in \{1, 2, 3, 4\}$

$$Unified.IO_{inter}^{mj,nk} = {IM^{nk.inter}}_{after\ scale} \cdot \frac{World.IO_{inter}^{mj,CHN.k}}{\sum_{m=\{USA,...,ROW\}} \sum_{j=\{1,...,4\}} \{World.IO_{inter}^{mj,CHN.k}\}}$$

$$Unified.IO_{final}^{mj,n} = {IM^{nk.final}}_{after\ scale} \cdot \frac{World.IO_{final}^{mj,CHN}}{\sum_{m=\{USA,...,ROW\}} \sum_{j=\{1,...,4\}} \{World.IO_{final}^{mj,CHN}\}}$$

Here, m represents the source region; j represents the source sector; n represents the destination region; k represents the destination sector. $Unified.IO_{inter}^{mj,nk}$ represents the value of sector j region m output, in the unified IO table , which is used as intermediate inputs in the production of goods in sector k region n. $Unified.IO_{final}^{mj,n}$ represents the value of sector j region m output, in the unified IO table, which is used for final consumption by region n. $World.IO_{inter}^{mj,CHN.k}$ represents the value of sector j region m output, in the World IO table , which is used as intermediate inputs in the production of goods in sector k of China. $World.IO_{final}^{mj,CHN}$ represents the value of sector j region m output, in the World IO table, which is used for final consumption by China.

Since I do not have data on how specific region in China source sectoral intermediate inputs or final goods from each of the foreign regions, I am using the source ratio of aggregate China from the World IO table instead. This serves as the inspiration behind the two equations mentioned above. Additionally, in Step 3, I have already scaled the sectoral imports and exports in the China IO table so that, for each sector, the aggregate import or export across China's regions matches exactly the total sectoral imports or exports for China in the World IO table. Implicitly, by the treatment of Step 3 and Step 5, a data concordance is achieved. This means that if we aggregate the unified IO table (part $IIIA$ and $IIIB$ in Figure D.2) across China's regions, the import-related data of the aggregated China will exactly match its counterparts in the World IO table (part $IIIAC$ and $IIIBC$ in Figure D.3).

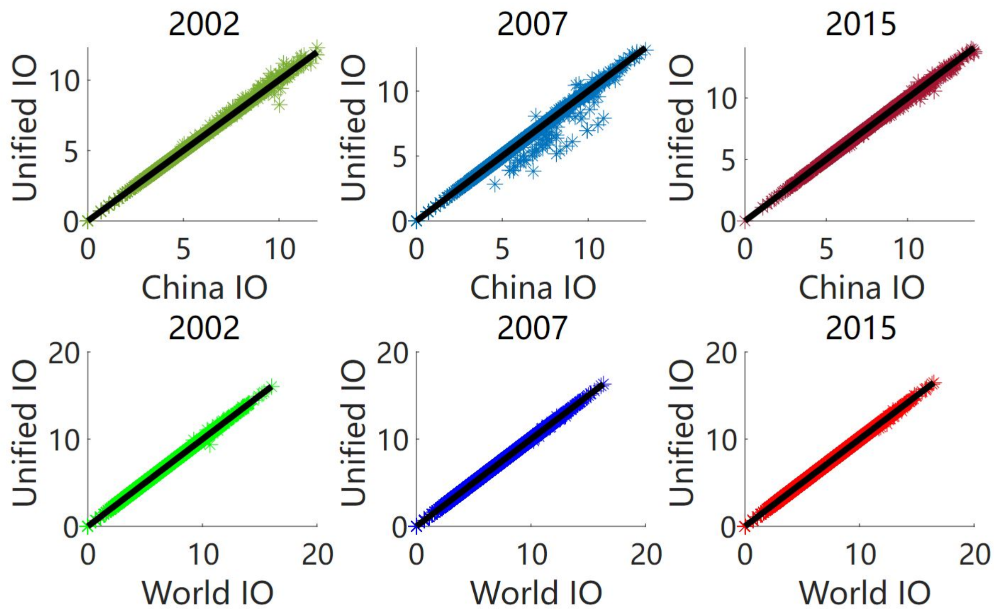
Step 6: Expand sectoral exports for specific China region in the China IO table.
Actually, this step extend area EX in Figure D.4 to area $II.A$ and $II.B$ in Figure D.2. To ensure that The Unified Inter-Region Input-Output (IRIO) table inherits good properties regarding China's sectoral exports between China and any foreign regions, I extend area EX in Figure D.4 in such a way that the sectoral exports between China and any foreign regions equal exactly the same value as those from the original World IO table:
for $\forall m \in \{A, ..., H\}$, $\forall j \in \{1, 2, 3, 4\}$

$$Unified.IO^{mj,nk}_{inter} = EX^{mj}{}_{after\ scale} \cdot \frac{World.IO^{mj,nk}_{inter}}{World.IO^{mj,n}_{final} + \sum_{n=\{USA,...,ROW\}} \sum_{k=\{1,...,4\}} \{World.IO^{mj,nk}_{inter}\}}$$

$$Unified.IO^{mj,n}_{final} = EX^{mj}{}_{after\ scale} \cdot \frac{World.IO^{mj,n}_{final}}{World.IO^{mj,n}_{final} + \sum_{n=\{USA,...,ROW\}} \sum_{k=\{1,...,4\}} \{World.IO^{mj,nk}_{inter}\}}$$

Similarly, since I lack data on how specific China's region's sectoral outputs allocate as sectoral intermediate inputs or as sectoral final goods across foreign regions, I employ the allocation ratio of aggregate China from the World IO table instead. This rationale underlies the two equations mentioned above. Additionally, in Step 3, I have already scaled sectoral imports and exports in the China IO table so that, for each sector, the aggregate imports or exports across China's regions exactly match the total sectoral imports or exports of China in the World IO table. Implicitly, the treatment of Step 3 and Step 6 together ensures data concordance, such that that if you aggregate the unified IO table (part IIA and IIB in Figure D.2) across China's regions, the export-relevant data of the aggregated China will exactly match its counterparts in the World IO table (part $IIAC$ and $IIBC$ in Figure D.3).

To verify the data accuracy of the unified IO table, I initially compare the values in the unified IO table with their corresponding values in either the original China or World IO table. As shown in Figure D.6, for each year, the scatter plots in the upper row display values from the original China IO table (depicted in Figure D.4) on the x-axis, and their corresponding calculated or directly obtained values from the Unified IO table (as presented in Figure D.2) on the y-axis, aligned along the 45-degree diagonal line. In the plots located in the bottom row, the x-axis represents values from the original World IO table (as illustrated in Figure D.3), and the y-axis displays their corresponding calculated or directly obtained values from the Unified IO table (as shown in Figure D.2), also aligned with the 45-degree diagonal line. From the observations in Figure D.6, it is evident that the unified IO table maintains a strong concordance with both its original China IO table and World IO table counterparts.



Note: This figure compare the values in the unified IO table with their corresponding values in either the original China or World IO table. For each year, the scatter plots in the upper row display values from the original China IO table (depicted in Figure D.4) on the x-axis, and their corresponding calculated or directly obtained values from the Unified IO table (as presented in Figure D.2) on the y-axis, aligned along the 45-degree diagonal line. In the plots located in the bottom row, the x-axis represents values from the original World IO table (as illustrated in Figure D.3), and the y-axis displays their corresponding calculated or directly obtained values from the Unified IO table (as shown in Figure D.2), also aligned with the 45-degree diagonal line.

Figure D.6
Data concordance from different sources

Then, I calculate and compare the key variable, the trade share of GDP, from different sources. As shown in Table D.4, the table lists the values of trade share of GDP and its sectoral components for each year and each type of trade (imports, exports, and trade across China's regions) as calculated from different sources. From the observations in Table D.4, it is evident that the different types of trade share indices and their components from various sources are almost equal, except for the inner trade share of GDP in the year 2007. The value calculated from the unified IO table is slightly lower than the value calculated from the China IO table. This inaccuracy can also be seen in the upper row of Figure D.6: for the year 2007, there are some points that deviate from the 45-degree line. The reason for this deviation may be that the China IO table of the year 2007 per se is not accurate enough, resulting in a discrepancy when comparing its aggregates with China's counterparts in the world IO tables. However, from the unified IO table, over the period 2002 to 2015, China's inner trade share is consistently increasing. This increase makes more sense in terms of conclusions drawn from other research. In conclusion, we can affirm that the unified IO table we have constructed maintains a high level of accuracy and reliability for relevant research.

TABLE D.4
TRADE SHARE DATA FROM DIFFERENT SOURCES

China Trade Share (% of GDP)		*Import (% GDP)*			*Export (% of GDP)*			*Inner Trade (% GDP)*	
		Source			*Source*			*Source*	
		Unfied IO	*World IO*	*WDI*	*Unfied IO*	*World IO*	*WDI*	*Unfied IO*	*China IO*
Total	*2002*	19.68%	19.68%	20.10%	23.46%	23.46%	22.64%	26.95%	26.95%
	2007	25.78%	25.97%	26.76%	36.39%	36.66%	35.43%	46.64%	51.26%
	2015	17.41%	17.39%	18.11%	20.03%	20.01%	21.35%	50.53%	50.53%
Agricultural Component	*2002*	0.48%	0.48%	-	0.37%	0.37%	-	1.37%	1.37%
	2007	0.80%	0.81%	-	0.31%	0.31%	-	2.31%	2.32%
	2015	0.61%	0.61%	-	0.14%	0.14%	-	2.23%	2.23%
Light Industry Component	*2002*	2.03%	2.03%	-	5.21%	5.21%	-	4.51%	4.51%
	2007	1.36%	1.37%	-	6.57%	6.61%	-	5.86%	6.95%
	2015	1.07%	1.07%	-	3.17%	3.17%	-	6.11%	6.11%
Heavy Industry Component	*2002*	15.16%	15.16%	-	12.98%	12.98%	-	16.33%	16.33%
	2007	20.77%	20.92%	-	24.05%	24.22%	-	27.85%	31.29%
	2015	10.08%	10.08%	-	13.13%	13.13%	-	24.41%	24.41%
Services Component	*2002*	2.01%	2.01%	-	4.91%	4.91%	-	4.74%	4.74%
	2007	2.86%	2.88%	-	5.47%	5.51%	-	10.61%	10.69%
	2015	5.65%	5.65%	-	3.59%	3.59%	-	17.79%	17.79%

Notes : This table lists the values of trade share of GDP and its sectoral components for each year and each type of trade (imports, exports, and trade across China's regions) as calculated from different sources. The World IO table are from three different years: 2002 and 2007 from the WIOD dataset, and 2015 from the OECD dataset.

APPENDIX E: GRAVITY EQUATION REGRESSION RESULTS IN THE CALIBRATION PART

This section list the results of gravity equation regression in the calibration part

APPENDIX F: ROBUSTNESS CHECK

F.1. Counterfactual Structural Decomposition under exogenous Trade Deficit

Given that trade deficit is exogenous to the model. When I do counterfactual, I deal with trade deficits in two different ways. Firstly, in the main part of the paper, I solve the model with all shocks and treat the trade deficits equal to zero. I then use the solved no-deficit world economy as baseline. Secondly, I calculate all counterfactual and baseline under fixed trade deficits to GDP ratio. When solving the model under a fixed trade deficit to GDP ratio, I ensure algorithm convergence and maintain a constant world GDP during updates of new wage guesses. To achieve this, I incorporate the trade deficit of the region ROW to balance

TABLE E.1
Gravity Equation Calibration Results

Sector	Agriculture			Light industry		
Year	2002	2007	2015	2002	2007	2015
VARIABLES	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)
log.distance	-2.18***	-1.80***	-1.30***	-1.82***	-1.65***	-0.94***
	(-6.96)	(-6.18)	(-4.78)	(-7.82)	(-8.66)	(-3.86)
Observations	110	110	110	110	110	110
R-squared	0.975	0.977	0.975	0.976	0.979	0.966
Importer FE	YES	YES	YES	YES	YES	YES
Exporter FE	YES	YES	YES	YES	YES	YES
Sector	Heavy industry			Service		
Year	2002	2007	2015	2002	2007	2015
VARIABLES	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)	ln(Xni/Xnn)
log.distance	-1.77***	-1.44***	-1.11***	-2.09***	-1.81***	-1.05***
	(-8.10)	(-8.66)	(-5.33)	(-7.84)	(-7.65)	(-3.73)
Observations	110	110	110	110	110	110
R-squared	0.976	0.980	0.970	0.982	0.981	0.967
Importer FE	YES	YES	YES	YES	YES	YES
Exporter FE	YES	YES	YES	YES	YES	YES

t-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

the trade deficit equations: $D_{ROW} = \sum_{i=1}^{N} X_{ni} - \sum_{i=1}^{N} X_{in} - \sum_{n \neq ROW} DG_n w_n L_n$, where DG_n represents the deficit to GDP ratio of region n. Throughout the main text, I solve the model with zero trade deficit in all of the counterfactual analyses. Additionally, I perform similar counterfactual analyses using an exogenous trade deficit ratio to ensure the robustness of the results. The conclusions drawn from these robustness checks are consistent with those presented in the main text.

Decompose trade share of GDP change

TABLE F.1
COUNTERFACTUAL EXPERIMENTS UNDER EXOGENOUS TRADE DEFICIT

Panel A	Average Marginal effects						Marginal effects	
07 v.s. 02	Trade Share of GDP (p.p. change)		Share of change		Standard deviation (-)		Trade Share of GDP (p.p. change)	
	External	Internal	Ex.	In.	Ex.	In.	Ex.	In.
All Forces	8.58	19.73	-	-	-	-	8.58	19.73
TFP	-8.85	1.45	-99.38%	7.50%	2.76	1.12	-12.46	1.70
Demographic								
Migration firction	2.05	1.21	23.06%	6.24%	1.53	0.66	2.31	1.60
Population growth	-0.31	0.02	-3.52%	0.13%	0.11	0.06	-0.37	0.04
Trade cost								
Intranational	-2.15	21.96	-24.13%	113.22%	0.48	1.00	-2.20	20.87
International	11.28	-2.10	126.62%	-10.84%	2.49	0.79	9.76	-1.66
Deficit-GDP ratio	0.24	-2.04	2.69%	-10.52%	0.54	0.55	-0.35	-2.36
Other forces	6.65	-1.11	74.67%	-5.72%	2.00	0.36	5.71	-1.25
Panel B	Average Marginal effects						Marginal effects	
15 v.s. 07	Trade Share of GDP (p.p. change)		Share of change		Standard deviation (-)		Trade Share of GDP (p.p. change)	
	External	Internal	Ex.	In.	Ex.	In.	Ex.	In.
All Forces	-10.51	5.97	-	-	-	-	-10.51	5.97
TFP	-11.20	1.88	98.07%	31.26%	1.78	2.77	-10.71	-0.43
Demographic								
Migration firction	-2.52	-0.98	22.09%	-16.34%	1.32	0.81	-1.95	0.13
Population growth	-0.66	0.17	5.78%	2.86%	0.20	0.32	-0.49	-0.12
Trade cost								
Intranational	-0.36	2.49	3.13%	41.50%	0.47	2.71	-0.42	-0.03
International	-1.51	-2.02	13.24%	-33.61%	3.95	0.83	-4.44	-1.22
Deficit-GDP ratio	0.73	1.36	-6.40%	22.59%	0.75	0.49	0.56	1.88
Other forces	4.10	3.11	-35.91%	51.73%	4.15	0.71	0.11	2.26

Notes: This table decomposes the changes in the international and intranational trade shares of GDP into contributions from 7 types of shocks: China's sectoral TFP shocks, China's regional initial labor supply shocks, migration friction shocks, China's internal trade cost shocks, China's international trade cost shocks, deficit to GDP ratio , and all other forces (including foreign economies' sectoral TFP shocks, foreign economies' labor supply shocks, and foreign economies' trade cost shocks). For each force, I report the average marginal effects across all 64 ($= 2^7/2$) possible pairs of permutations . The share of change is the individual force's average marginal effect relative to the sum of all average marginal effects. The standard deviation column reports the standard deviation of the individual force's effects, calculated from all 64 possible pairs of permutations. The marginal effects represent the change in trade share when a particular force is kept fixed at the base-year level while other forces change as usual. These effects are calculated from one pair of permutations. External column records the average of China's export and import share of GDP.

TABLE F.2

Counterfactual experiments under exogenous trade deficit

Panel A	Average Marginal effects									Marginal effects		
07 v.s. 02	Trade Share of GDP (p.p. change)			Share of change (%)			Standard deviation (-)			Trade Share of GDP (p.p. change)		
	Ex.	Im.	Internal	Ex.	Im.	In.	Ex.	Im.	In.	Ex.	Im.	In.
All Forces	12.00	5.15	19.73	-	-	-	-	-	-	12.00	5.15	19.73
TFP	-9.45	-8.26	1.45	-75.98%	-153.35%	7.50%	2.76	2.72	1.12	-13.28	-11.64	1.70
Demographic												
Migration firction	2.69	1.42	1.21	21.65%	26.31%	6.24%	1.53	1.12	0.66	4.10	0.52	1.60
Population growth	-0.33	-0.30	0.02	-2.67%	-5.48%	0.13%	0.11	0.09	0.06	-0.41	-0.33	0.04
Trade cost												
Intranational	-2.43	-1.87	21.96	-19.59%	-34.63%	113.22%	0.48	0.52	1.00	-2.24	-2.16	20.87
International	11.31	11.25	-2.10	91.01%	208.77%	-10.84%	2.49	2.55	0.79	9.95	9.57	-1.66
Deficit-GDP ratio	3.85	-3.37	-2.04	30.94%	-62.47%	-10.52%	1.50	1.28	0.55	4.72	-5.42	-2.36
Other forces	6.79	6.51	-1.11	54.65%	120.85%	-5.72%	2.00	1.98	0.36	5.85	5.58	-1.25
Panel A	**Average Marginal effects**									**Marginal effects**		
15 v.s. 07	Trade Share of GDP (p.p. change)			Share of change (%)			Standard deviation (-)			Trade Share of GDP (p.p. change)		
	Ex.	Im.	Internal	Ex.	Im.	In.	Ex.	Im.	In.	Ex.	Im.	In.
All Forces	-14.52	-6.49	5.97	-	-	-	-	-	-	-14.52	-6.49	5.97
TFP	-11.50	-10.91	1.88	73.77%	150.19%	31.26%	1.78	1.67	2.77	-11.30	-10.11	-0.43
Demographic												
Migration firction	-3.40	-1.65	-0.98	21.80%	22.70%	-16.34%	1.32	0.98	0.81	-1.79	-2.11	0.13
Population growth	-0.82	-0.50	0.17	5.27%	6.89%	2.86%	0.20	0.15	0.32	-0.56	-0.43	-0.12
Trade cost												
Intranational	-0.08	-0.64	2.49	0.48%	8.80%	41.50%	0.47	0.57	2.71	-0.07	-0.76	-0.03
International	-1.45	-1.58	-2.02	9.30%	21.69%	-33.61%	3.95	3.77	0.83	-4.44	-4.44	-1.22
Deficit-GDP ratio	-2.45	3.91	1.36	15.69%	-53.80%	22.59%	1.56	1.00	0.49	-1.55	2.67	1.88
Other forces	4.10	4.10	3.11	-26.32%	-56.47%	51.73%	4.15	3.97	0.71	0.11	0.11	2.26

Notes: This table decomposes the changes in the international and intranational trade shares of GDP into contributions from 7 types of shocks: China's sectoral TFP shocks, China's regional initial labor supply shocks, migration friction shocks, China's internal trade cost shocks, China's international trade cost shocks, deficit to GDP ratio , and all other forces (including foreign economies' sectoral TFP shocks, foreign economies' labor supply shocks, and foreign economies' trade cost shocks). For each force, I report the average marginal effects across all 64 ($= 2^7/2$) possible pairs of permutations . The share of change is the individual force's average marginal effect relative to the sum of all average marginal effects. The standard deviation column reports the standard deviation of the individual force's effects, calculated from all 64 possible pairs of permutations. The marginal effects represent the change in trade share when a particular force is kept fixed at the base-year level while other forces change as usual. These effects are calculated from one pair of permutations.

Decompose trade share of GDP change at sector level

TABLE F.3
Counterfactual experiments under exogenous trade deficit

Panel A	Decompose Marginal effects at sector level				
07 v.s. 02	Trade Share of GDP (p.p. change)				
	External	Internal		External	Internal
TFP	**-12.46**	**1.70**	***International Trade cost***	**9.76**	**-1.66**
Agriculture	-0.43	-0.08	Agriculture	-0.19	-0.01
Light industry	-1.63	0.01	Light industry	0.67	-0.14
Heavy industry	-9.40	5.30	Heavy industry	6.80	-0.10
Service	-7.26	-3.25	Service	0.58	-0.92
Intranational Trade cost	**-2.20**	**20.87**	***All Forces***	**8.58**	**19.73**
Agriculture	0.01	0.89	***Other forces***	5.71	-1.25
Light industry	-0.08	2.64	Foregin TFP	5.60	-1.35
Heavy industry	-1.99	11.15	Foregin trade cost	-0.55	0.20
Service	0.05	4.95	Foregin labor	0.73	-0.14
Panel B	Decompose Marginal effects at sector level				
15 v.s. 07	Trade Share of GDP (p.p. change)				
	External	Internal		External	Internal
TFP	**-10.71**	**-0.43**	***International Trade cost***	**-4.44**	**-1.22**
Agriculture	-4.68	-0.80	Agriculture	-1.89	-0.18
Light industry	-0.86	0.03	Light industry	-0.43	0.10
Heavy industry	-8.61	5.26	Heavy industry	-1.10	1.10
Service	-13.88	-4.40	Service	-4.56	-1.74
Intranational Trade cost	**-0.42**	**-0.03**	***All Forces***	**-10.51**	**5.97**
Agriculture	0.01	-0.15	***Other forces***	0.11	2.26
Light industry	0.02	-1.13	Foregin TFP	0.52	2.08
Heavy industry	0.20	-3.35	Foregin trade cost	-0.77	0.26
Service	-0.10	2.43	Foregin labor	0.55	-0.08

TABLE F.4

Counterfactual experiments under exogenous trade deficit

Panel A	Decompose Marginal effects at sector level						
07 v.s. 02	Trade Share of GDP (p.p. change)						
	Export	Import	Internal		Export	Import	Internal
TFP	**-13.28**	**-11.64**	**1.70**	***International Trade cost***	**9.95**	**9.57**	**-1.66**
Agr.	-0.61	-0.25	-0.08	Agr.	-0.20	-0.18	-0.01
Lig.	-1.99	-1.27	0.01	Lig.	0.68	0.66	-0.14
Hea.	-10.01	-8.79	5.30	Hea.	6.90	6.70	-0.10
Ser.	-6.99	-7.53	-3.25	Ser.	0.62	0.54	-0.92
Intranational Trade cost	**-2.24**	**-2.16**	**20.87**	***All Forces***	**12.00**	**5.15**	**19.73**
Agr.	0.00	0.03	0.89	***Other forces***	5.85	5.58	-1.25
Lig.	-0.07	-0.08	2.64	Foregin TFP	5.74	5.47	-1.35
Hea.	-2.06	-1.91	11.15	Foregin trade cost	-0.57	-0.53	0.20
Ser.	0.10	0.00	4.95	Foregin labor	0.75	0.71	-0.14
Panel B	Decompose Marginal effects at sector level						
15 v.s. 07	Trade Share of GDP (p.p. change)						
	Export	Import	Internal		Export	Import	Internal
TFP	**-11.30**	**-10.11**	**-0.43**	***International Trade cost***	**-4.44**	**-4.44**	**-1.22**
Agr.	-4.80	-4.57	-0.80	Agr.	-1.91	-1.86	-0.18
Lig.	-0.85	-0.88	0.03	Lig.	-0.43	-0.43	0.10
Hea.	-8.55	-8.67	5.26	Hea.	-1.09	-1.11	1.10
Ser.	-14.49	-13.27	-4.40	Ser.	-4.59	-4.53	-1.74
Intranational Trade cost	**-0.07**	**-0.76**	**-0.03**	***All Forces***	**-14.52**	**-6.49**	**5.97**
Agr.	0.00	0.02	-0.15	***Other forces***	0.11	0.11	2.26
Lig.	0.02	0.02	-1.13	Foregin TFP	0.52	0.51	2.08
Hea.	0.18	0.22	-3.35	Foregin trade cost	-0.77	-0.76	0.26
Ser.	0.19	-0.39	2.43	Foregin labor	0.55	0.54	-0.08

Notes: This table decomposes the changes in the international and intranational trade shares of GDP, attributing them to various factors such as China's TFP change, changes in intranational trade costs, and changes in international trade costs at the sector level. Additionally, it also decompose the 'Other forces' at a more disaggregated level. For each of these shocks, the model is solved while holding the shocks specific to a particular sector or more dis-aggregated shocks at the base year level, while allowing all other shock changes to occur over time. I then compare this result with the baseline case. External column records the average of China's export and import share of GDP.

TABLE F.5

Counterfactual experiments under exogenous trade deficit

Panel A	Decompose Marginal effects at sector level								
07 v.s. 02	Trade Share of GDP (p.p. change)								
	External	Export	Import	Internal		External	Export	Import	Internal
TFP	**-12.46**	**-13.28**	**-11.64**	**1.70**	***International Trade cost***	**9.76**	**9.95**	**9.57**	**-1.66**
Agr.	-0.43	-0.61	-0.25	-0.08	Agr.	-0.19	-0.20	-0.18	-0.01
Lig.	-1.63	-1.99	-1.27	0.01	Lig.	0.67	0.68	0.66	-0.14
Hea.	-9.40	-10.01	-8.79	5.30	Hea.	6.80	6.90	6.70	-0.10
Ser.	-7.26	-6.99	-7.53	-3.25	Ser.	0.58	0.62	0.54	-0.92
Intranational Trade cost	**-2.20**	**-2.24**	**-2.16**	**20.87**	***All Forces***	**8.58**	**12.00**	**5.15**	**19.73**
Agr.	0.01	0.00	0.03	0.89	***Other forces***	5.71	5.85	5.58	-1.25
Lig.	-0.08	-0.07	-0.08	2.64	Foregin TFP	5.60	5.74	5.47	-1.35
Hea.	-1.99	-2.06	-1.91	11.15	Foregin trade cost	-0.55	-0.57	-0.53	0.20
Ser.	0.05	0.10	0.00	4.95	Foregin labor	0.73	0.75	0.71	-0.14
Panel B	Decompose Marginal effects at sector level								
15 v.s. 07	Trade Share of GDP (p.p. change)								
	External	Export	Import	Internal		External	Export	Import	Internal
TFP	**-10.71**	**-11.30**	**-10.11**	**-0.43**	***International Trade cost***	**-4.44**	**-4.44**	**-4.44**	**-1.22**
Agr.	-4.68	-4.80	-4.57	-0.80	Agr.	-1.89	-1.91	-1.86	-0.18
Lig.	-0.86	-0.85	-0.88	0.03	Lig.	-0.43	-0.43	-0.43	0.10
Hea.	-8.61	-8.55	-8.67	5.26	Hea.	-1.10	-1.09	-1.11	1.10
Ser.	-13.88	-14.49	-13.27	-4.40	Ser.	-4.56	-4.59	-4.53	-1.74
Intranational Trade cost	**-0.42**	**-0.07**	**-0.76**	**-0.03**	***All Forces***	**-10.51**	**-14.52**	**-6.49**	**5.97**
Agr.	0.01	0.00	0.02	-0.15	***Other forces***	0.11	0.11	0.11	2.26
Lig.	0.02	0.02	0.02	-1.13	Foregin TFP	0.52	0.52	0.51	2.08
Hea.	0.20	0.18	0.22	-3.35	Foregin trade cost	-0.77	-0.77	-0.76	0.26
Ser.	-0.10	0.19	-0.39	2.43	Foregin labor	0.55	0.55	0.54	-0.08

Notes: This table decomposes the changes in the international and intranational trade shares of GDP, attributing them to various factors such as China's TFP change, changes in intranational trade costs, and changes in international trade costs at the sector level. Additionally, it also decompose the 'Other forces' at a more disaggregated level. For each of these shocks, the model is solved while holding the shocks specific to a particular sector or more dis-aggregated shocks at the base year level, while allowing all other shock changes to occur over time. I then compare this result with the baseline case.