THE DECLINE IN CHINA'S TRADE SHARE OF GDP: A STRUCTURAL ACCOUNTING *

YANG PEI †

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ABSTRACT

China's trade share of GDP has been declining since 2007. To understand this, I develop a multi-sector, multi-region Ricardian trade model to quantify the forces driving changes in China's trade share of GDP from 2002 to 2015. The model features three main types of time-varying shocks: productivity shocks, trade cost shocks, and labor mobility cost shocks. These shocks affect China's trade through comparative advantage and specialization. I calibrate the model and conduct structural accounting decompositions. The results indicate that changes in productivity and trade costs for both China and foreign regions together account for about 87% of the change in China's trade share of GDP. From 2002 to 2007, the decrease in China's international trade costs and the growth in foreign productivity were the main factors driving the increase in trade share. From 2007 to 2015, China's productivity growth became the primary factor reducing the trade share. Moreover, in contrast to the earlier period, China's international trade costs change also contributed to the decline in its trade share.

Keywords: China's trade share of GDP; Comparative advantage; Specialization; Migration; Intranational trade; trade cost; productivity.
JEL code: F11, F43, O53.

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†Department of Economics, University of Houston. E-mail: ypei1.work@gmail.com.

1. Introduction

The economic growth of China is one of the most important changes in the world economy over the last several decades. A key feature of this growth is China's increased participation in the global economy, particularly through international trade. Alongside China's increasing share of world GDP and world trade, a puzzling trend has emerged: China's trade share of GDP has been steadily declining since the mid-2000s.

This puzzling downward trend reflects, of course, that China's GDP growth exceeds its trade growth. However, this is not an explanation. As we know from trade theory, several factors, including trade costs, productivity, and endowments, play crucial roles in shaping both trade and GDP dynamics. Countries with low intranational trade costs or high international import trade costs tend to rely more on domestic production and less on international trade. This reduces the import share of total expenditure, thereby lowering the import share of GDP.[1] Additionally, low production costs, arising from high productivity or an abundance of endowments such as labor, allow countries to produce a wider range of goods domestically, resulting in a lower trade share of GDP.

In this paper, I develop and calibrate a model that captures the aforementioned mechanisms. The model is a multi-sector, multi-region Ricardian trade model, drawing from Eaton and Kortum (2002), Caliendo and Parro (2015), and Tombe and Zhu (2019). The model features input-output linkages, international trade, inter-regional trade within China, and labor flow across regions within China. The main "shocks" (or "wedges") include regional-sectoral productivity shocks, inter-regional-sectoral trade cost shocks, and inter-regional labor mobility cost shocks. These shocks capture the forces behind China's growing importance in the global economy and its increasing domestic economic integration during the period under study.

I calibrate the model, which successfully recovers the evolution of China's trade share of GDP. Then, I conduct structural accounting decompositions to evaluate the contributions of trade integration, productivity growth, and labor flow to the changes in China's trade share of GDP. The analysis reveals that variations in productivity and trade costs, for both China and foreign regions, account for approximately 87% of the changes in China's trade share of GDP. From 2002 to 2007, the primary drivers of the increase in China's trade share were the reduction in China's international trade costs and productivity growth in foreign regions. From 2007 to 2015, productivity growth in China emerges as the dominant force behind the decrease in its trade share of GDP. Although the reduction in China's import

1. Similarly, in countries with high international export trade costs, fewer domestically produced goods are exported. This reduces the share of exports in total production, thereby lowering the export share of GDP.

trade costs contributed to an increase, this effect was more than offset by the rising export trade costs, which drove the trade share down.

In the model, China's trade-to-GDP ratio is fundamentally influenced by its relative productivity compared to foreign countries, trade costs between its regions, international trade costs, and labor supply. The labor supply in each of China's regions is endogenous and primarily depends on migration flows, which, in turn, are influenced by regional productivity and labor mobility costs between China's regions. These factors impact China's trade share of GDP through comparative advantage and specialization.

First, as China's productivity improves, comparative advantage forces enable it to produce a broader range of goods for domestic consumption while importing fewer varieties from abroad. Consequently, the proportion of total spending on domestic goods rises, resulting in a decrease in the import share of GDP.[2]Additionally, productivity growth in one sector can influence others through Input-Output (IO) Linkages. For instance, if heavy industry heavily relies on intermediate inputs from the services sector, increased productivity in services will significantly reduce the production cost of heavy industry. It will also impact the trade share, particularly if heavy industry plays a crucial role in trade.

Second, as China's intranational trade costs rise or its international import trade costs decrease, the country is incentivized to import a broader range of goods from external sources. All else equal, this leads to an increase in expenditure on foreign goods, resulting in a higher import share of GDP. Conversely, if international export trade costs for China's regions decline, the country will export a greater variety of domestically produced goods. This increase in the variety of exported goods will elevate the share of exports in total production, thus raising the export share of GDP.

Third, as labor mobility costs across China's regions decrease, labor moves from low-productivity to high-productivity regions. In high-productivity regions, the net inflow of labor increases the labor supply, which further reduces production costs. Consequently, these regions produce a greater variety of goods domestically, reducing the reliance on imports and thus decreasing the trade share. Conversely, low-productivity regions experience labor outflow, leading to increased production costs. These regions will specialize in fewer varieties and rely more on imports, thereby increasing the trade share. Therefore, the net impact of decreased labor mobility costs depends on which mechanism is dominant.

I evaluate the effects of each of these shocks through a model-based structural accounting decomposition. The model is implemented across 11 regions (8 regions in mainland China and 3 foreign regions) and 4 sectors (Agriculture, Light Industry, Heavy Industry, and Services).

2. Simultaneously, the export share of GDP decreases, despite the greater variety of exported goods, because productivity improvements reduce export prices. Furthermore, export trade must be balanced by import trade.

Due to data availability, the implementation covers the years 2002, 2007, and 2015. To calibrate the time-varying shocks, I extend the methodology developed by Eaton and Kortum (2002), which is also employed in Waugh (2010), Levchenko and Zhang (2016), Tombe and Zhu (2019), and Santacreu, Sposi, and Zhang (2023). Specifically, I begin by estimating regional-level importer fixed effects for each sector and year using the model-implied gravity equation. These estimated fixed effects provide insights into productivity and production costs. However, they are identified relative to the base region, which makes productivity shocks non-comparable over time. To address this issue, rather than normalizing the fixed effects for the base region to zero, I estimate them using its annual sectoral intermediate goods prices and the analytical relationships implied by the model. Using these time-comparable fixed effects, I then calibrate the time-varying shocks using analytical equations derived from the model.

The calibration results indicate that the early period in China was marked by increased productivity, reduced trade costs, and lower labor mobility costs. In the later period, similar patterns were observed, with exceptions in import and intranational trade costs. Specifically, China's weighted average productivity grew by 32.2% in the first period and 51.9% in the later period. The services sector experienced the most significant changes among the four sectors in both periods. Labor mobility costs decreased by 13.3% in the early period and 11.8% in the later period. Export trade costs fell by 22.6% in the early period and 23.4% in the later period. In contrast, import trade costs remained nearly constant in the initial period but increased by approximately 15.1% in the subsequent period. Intranational trade costs decreased significantly by 12% in the early period but saw a slower reduction of only 1.2% in the later period. These calibrated time-varying shocks align with intuitive expectations and closely replicate real-world data.

To quantify the changes in China's trade share of GDP attributable to a particular force, I employ structural accounting decompositions by comparing scenarios with and without this specific shock. Specifically, I first solve the model in the absence of change in a particular force. I then compare this result with the baseline result, where all shocks are realized. From 2002 to 2007, two principal factors contributed to the increase in China's trade share of GDP: declining international trade costs and the productivity growth of foreign regions, which drove up the trade share of GDP by 6.8 percentage points (p.p.) and 4.7 p.p., respectively. The productivity growth of China's regions is equally important, but it exerts its effects in an inverse direction, resulting in an 8.4 p.p. decrease in China's trade share of GDP.

From 2007 to 2015, China's productivity growth emerged as the primary and dominant factor contributing to the reduction in its trade share of GDP, resulting in a 12.5 percentage point (p.p.) decline. Additionally, China's increasing export trade costs had a more significant negative impact on its trade share than the reduction in import trade costs; the overall effect of these two costs implies a reduction of China's trade share of 3.6 pp. At the sector level, during both periods, although the services component of trade accounts for a relatively small portion of the total trade share of GDP change, through input-output linkages, the productivity growth in China's services sector is as important as the productivity growth in China's heavy industry sector in driving changes in the trade share of GDP. Overall, from 2002 to 2015, changes in productivity and trade costs for both China and foreign regions together account for approximately 87% of the fluctuations in China's trade share of GDP.

I also quantify the forces that drive changes in other macroeconomic variables, including China's intranational trade share of GDP and real income per worker. The results reveal that, during the first period, the primary driver of the increase in China's intranational trade share of GDP was the reduction in intranational trade costs, which contributed an increase of 14.3 percentage points (p.p.). However, in the subsequent period, changes in intranational trade costs led to a decrease in the intranational trade share by 4 p.p. Regarding real income per worker, productivity increases are the dominant forces driving its increase in both periods, and its effects are more prominent than other forces. As for the effect of other forces on real income per worker, in the first period, the decline in intranational trade costs resulted in a 4% increase in real income per worker, exceeding the impact of the reduction in international trade costs, which was 2.7%. In the later period, aside from productivity growth, the decrease in labor mobility costs emerged as the second most significant factor, contributing to a 4.5% increase in real income per worker.

The paper is most closely related to Tombe and Zhu (2019), which examines how policy reforms in China from 2000 to 2005 reduced internal trade costs and migration costs and quantifies their effects. The study finds that reductions in internal trade and migration costs together contribute to 36% of China's overall labor productivity growth from 2000 to 2005, and this effect exceeds the effects of reductions in external trade costs. My paper focuses on explaining the mechanisms of each of these forces driving China's declining trade share of GDP and quantifying the impact of each force. I further extend the period to include 2007–2015 and encompass more sectors and regions.

The paper is also closely related to Brandt and Lim (2024), which focuses on decomposing the growth of exports from 2000 to 2013. My paper focuses on decomposing the decline in the trade share of GDP after 2006. The difference between export levels and the trade share of GDP matters; for example, in their paper, higher China TFP growth leads to an increase in exports, but a decline in the trade share of GDP. In addition, their paper studies both the firm-level data and aggregate outcomes, and uses a Melitz model. My paper focuses on aggregate outcomes and uses an Eaton and Kortum-type model. My model allows for general equilibrium forces from China to affect foreign countries prices and expenditure - these are exogenous in their paper.

The paper is related to the literature linking trade with the geographical distribution of economic activity. This literature includes studies such as Caliendo and Parro (2015), Allen and Arkolakis (2014), Redding (2016), 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). Besides interregional trade and international trade, I further incorporate labor flow under frictions across China's regions in a manner similar to Allen and Arkolakis (2014) Ahlfeldt, Redding, Sturm, and Wolf (2015), Redding (2016), Tombe and Zhu (2019). This strand of literature primarily focuses on the welfare implications of several exogenous forces, including but not limited to changes in tariffs, labor mobility costs, and productivity. My paper focuses on explaining the mechanism responsible for changing an economy's trade share of GDP as implied by the Ricardian trade model I have developed.

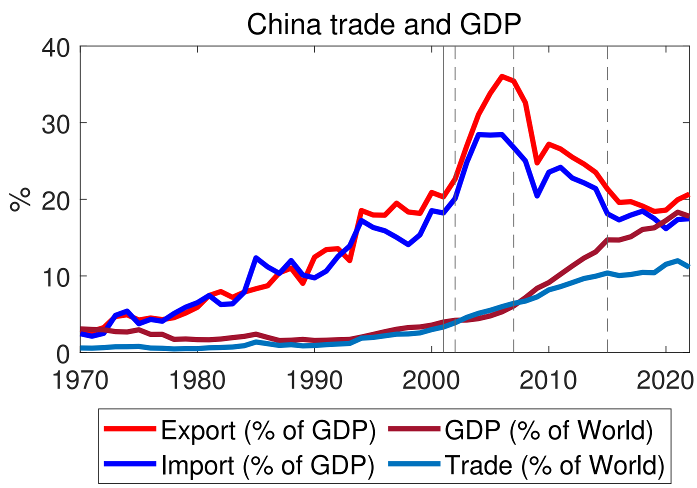
The paper is also related to two strands of literature on trade and the Chinese economy. The first strand is the research on quantifying the consequences of trade on China, either at the aggregate or distributional level. This research often incorporates internal migration and internal trade across China's regions into the model, emphasizing the effects of internal migration or internal trade to varying degrees depending on the paper's focus. This strand is represented by papers such as those by Tombe and Zhu (2019), Fan (2019), Hao, Sun, Tombe, and Zhu (2020) and Ma and Tang (2020).

The second strand is the research on explaining and quantifying the source of China's export dynamics or trade imbalance. Specifically, Alessandria, Choi, and Lu (2017) examines China's growth and integration, in terms of both trade and finance, within a two-country DSGE model. Their primary focus lies in analyzing the impact of alterations in trade barriers on China's trade balance and the accumulation of foreign assets. Liu and Ma (2018) develops a multi-sector Melitz type trade model that incorporates heterogeneous firms' and workers' location choices to analyze China's export surge from 1990 to 2005. Similarly, as mentioned earlier, Brandt and Lim (2024) also focus on export levels but extend the analysis period from 2000 to 2013. Recently, Alessandria, Khan, Khederlarian, Ruhl, and Steinberg (2021) studied the growth of Chinese exports to the United States over 50 years from a dynamic perspective and emphasized the importance of trade policy expectations in explaining the effects of policy changes on the dynamics of trade flows. My paper focuses on quantifying the change in China's trade share of GDP instead of the level of trade deficit or exports, which has yet to be explored in previous papers.

The rest of the paper is organized as follows. Section 2 provides motivating facts. Section 4 lays out the model and explains the mechanisms. Section 5 describes the data, calibrates the main parameters and shocks, and then briefly discusses the calibrated shocks. Section 6 conducts counterfactual structural decompositions and analyzes the results. Section 7 concludes.

2. Motivating Facts

In this section, I present some key facts concerning Chinese trade and GDP dynamics. First, I describe changes in China's trade share of GDP and compare them with those of other economies. Second, I analyze the disaggregated behavior of China's trade share of GDP changes at the sector level, importer level across China's regions, and exporter level across foreign countries. Specifically, at the sector level, I decompose changes in China's trade share of GDP into "within-sector" and "between-sector" effects. Third, I demonstrate that, during the same period as China's trade and GDP changes, the country experienced significant internal economic integration, as evidenced by changes in its intranational trade share of GDP and cross-province migration.



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. The trade share of GDP is calculated as the average of imports and exports as a percentage of GDP. The data are sourced from the World Development Indicators (WDI) database.

Figure 1
China trade and GDP data

Overall changes As one of the most common measures of "trade openness," the ratio of trade to GDP provides insight into the extent to which a country's economy is connected to the global economy through trade.[3] As depicted in Figure 1, from 1970 to 2020, China's trade share of world trade consistently increased, with a notable acceleration after 2000. During the same period, China's GDP share of world GDP followed a similar upward trend. However, despite the continued growth in both China's GDP share of world GDP and its trade share of world trade, its trade share of GDP has reversed its several-decade upward

3. See Spilimbergo, Londoño, and Székely (1999), Rodrik (2002), Dollar and Kraay (2003), Yanikkaya (2003), Dollar and Kraay (2004), Giovanni and Levchenko (2009).

trend and begun declining from the mid-2000s. Specifically, China's average export and import trade share of GDP peaked at 32.2% in 2006. Since then, it has declined, reaching 19.1% in 2022. This level is even lower than the 19.7% in 2000 before China joined the WTO.

Compared to other countries, China's trade share of GDP experienced more rapid growth, especially during 2001–2006, with both levels and slopes surpassing those of most developed and developing nations.[4] After 2006, it also declined more rapidly, whereas many other countries either maintained their previous trends or levels. India shows a similar pattern to China, but its trade share peaked in 2011 at a lower level, with overall variations being less pronounced compared to China.

Changes across sectors, China's regions, and foreign regions To further analyze the change in China's trade share of GDP at a more disaggregated level, I first decompose the changes in China's trade share of GDP into "within-sector" and "between-sector" effects. I then decompose China's international trade across China's regions or foreign economy groups by the share of China's aggregate GDP.[5]

The aggregate change in China's trade share of GDP can be decomposed at the sector level into two components:

$$\Delta \frac{\sum_k T_k}{\sum_k Y_k} \equiv \sum_k \left(\bar{\omega}_k \cdot \Delta S_k + \Delta \omega_k \cdot \bar{S_k} \right), \tag{1}$$

where Y_k, T_k are China's GDP and international trade in sector k at time t, respectively. The term ω_k is defined as sector k's GDP share, $\omega_k = Y_k / \sum_k Y_k$. The term S_k is defined as sector k's trade share of sector k's GDP, $S_k = T_k/Y_k$. The average and change of variable X is defined as $\bar{X} = (X_{t=1} + X_{t=0})/2$ and $\Delta X = X_{t=1} - X_{t=0}$, respectively.

The first term, the within-sector effect, is the change in the sector-level trade-GDP ratio weighted by the average sectoral GDP share over time. The second term, the between-sector effect, is the change in sectoral GDP share weighted by the average of the sector-level trade-GDP ratio over time. This decomposition reveals that if China's trade-GDP ratio declines, there are two sources of change. One is that the individual sector's trade-GDP ratio declines (within-sector effect). The other is that sectoral GDP changes as resources are reallocated to sectors that have a low trade-GDP ratio (between-sector effect).

4. Check Appendix A for more details.

5. The eight regions within mainland China are: A. Northeast, B. Beijing and Tianjin, C. Northern Coastal, D. Eastern Coastal, E. Southern Coastal, F. Central, G. Northwest, and H. Southwest.

TABLE 1
Decomposition of China's Trade Share Change

Export (% of GDP)	**2002 to 2007**			**2007 to 2015**		
Change	Total	Within	Between	Total	Within	Between
Total	13.2	11.8	1.3	-16.6	-14.0	-2.6
Agriculture	-0.1	0.0	-0.1	-0.2	-0.1	-0.1
Light Industry	1.4	2.0	-0.6	-3.4	-3.1	-0.3
Heavy Industry	11.2	9.3	1.9	-11.1	-8.1	-3.0
Service	0.6	0.5	0.1	-1.9	-2.7	0.7

Notes: This table is constructed based on data from the WIOD table, and it embodies sector-level bilateral trade flows across China's and foreign economies. See Appendix E for details.

Table 1 illustrates the decomposition of China's export share of GDP across sectors. Given that the decomposition of imports exhibits a similar pattern, only the export decomposition is presented here. The complete results are included in Appendix E.

The main takeaway is that heavy industry is the key sector for both the increasing trade-GDP ratio period and the recent decline. For the heavy industry sector, the within effect is dominant compared to the between effect. That is, the majority of China's trade share of GDP change is accounted for by the heavy industry sector, which traded a larger value relative to its sectoral GDP in the early period and traded a smaller value relative to its sectoral GDP in the later period.

TABLE 2
China trade share data

China's average trade (% of GDP)	**2002**	**2007**	**2015**
Total	21.6	31.1	18.7
Classified by China regions			
NorthEast (NE)	1.2	2.0	0.7
BeijingTianjin (BT)	1.7	2.8	1.6
NorthernCoastal (NC)	1.6	2.8	1.8
EasternCoastal (EC)	7.1	10.8	6.1
SouthernCoastal (SC)	8.3	7.5	6.1
Central (CE)	0.8	2.2	1.0
NorthWest (NW)	0.4	1.6	0.5
SouthWest (SW)	0.5	1.3	0.8
Classified by foreign countries or regions			
USA	2.9	4.0	3.2
JPN	2.8	3.0	1.5
KOR	1.3	1.9	1.4
G6	5.3	7.9	5.5
AS3	5.4	6.5	3.7
ROW	10.9	16.7	9.5

Notes: The average trade share of GDP is calculated as the average of imports and exports as a percentage of GDP. This table is constructed based on the data from the WIOD table and the China IO table, which embodies sector-level bilateral trade flows across China and foreign economies. See Appendix E for details.

The top panel of Table 2 provides a breakdown of China's trade across its regions, divided by China's aggregate GDP for the three listed years. Overall, during both periods, the changes in trade in the Eastern Coastal and Southern Coastal regions account for the main changes in trade share.

The bottom panel of Table 2 reports a breakdown of China's trade across its primary trade partners or country groups, divided by China's aggregate GDP for the three listed years. The United States emerged as China's largest single-country trading partner, followed by Japan and South Korea in that order. In both periods, these top three single-country trading partners exhibited similar trends of change as the aggregate.

Among foreign economic groups, the "G6" (comprising the G7 economies excluding Japan) and the "Asian 3" (Japan, South Korea, and Taiwan) were equally significant. Together, they accounted for almost half of China's total trade share change, slightly less than the trade share change due to the rest of the world combined. In both periods, these three economic groups also showed similar trends to the aggregate change.

Overall, in both periods, China's change in trade share is not driven by a single trade partner or a single trade partner group. Instead, it is driven by the overall change in trade between China and all of its trading partners as a share of China's aggregate GDP.

Internal economic integration Concurrent with China's increasing importance in the global economy, it has also experienced substantial internal economic integration, as widely discussed in the literature.[6] Specifically, China's intranational trade share of GDP increased from approximately 27% in 2002 to about 51% in 2015.[7] From 2000 to 2015, the proportion of cross-province migrations in total employment rose from around 14% to approximately 28%, as reported by Hao, Sun, Tombe and Zhu (2020).

Policy reforms targeting the household registration system, which aim to ease regulations on internal migration, combined with extensive infrastructure development and other related institutional reforms, are likely to have played instrumental roles in driving these internal dynamics. These forces underlying China's internal economic integration may also impact its trade and GDP dynamics.

Summary Overall, I describe the facts regarding China's trade share of GDP change and present the main features and backgrounds of this change. These insights motivate the structural model developed in Section 4 and underpin the implementation of the model presented in Section 5 and Section 6.

6. See Xu and Fan (2012), Fan (2019), Tombe and Zhu (2019), Facchini, Liu, Mayda, and Zhou (2019), Hao, Sun, Tombe and Zhu (2020), Ma and Tang (2020), Zi (2020), An, Qin, Wu, and You (2024).

7. China's intranational trade share of GDP is calculated based on data from the China IO table.

3. Model

The model I developed is a static multi-sector, multi-region Ricardian trade model, based on the framework from Eaton and Kortum (2002) and Caliendo and Parro (2015). The model features inter-regional labor flows across China's regions, similar to Tombe and Zhu (2019).[8]The model also features input-output linkages, international trade, and inter-regional trade within China. All markets are perfectly competitive. Trade costs follow the usual iceberg form.

3.1. Production

The model consists of N_0 regions within mainland China and $N_1 = N - N_0$ foreign regions. For each region n and sector j, there is a continuum of intermediate varieties $\omega^j \in [0,1]$. The sectoral intermediate variety is tradable and is produced by local competitive firms with Cobb-Douglas technology:

$$y_{n,t}^{j}(\omega) \equiv q_{n,t}^{j}(\omega)\left[L_{n,t}^{j}(\omega)^{\beta_n^j} K_{n,t}^{j}(\omega)^{1-\beta_n^j}\right]^{\gamma_n^j} \prod_{k=1}^{J} m_{n,t}^{k,j}(\omega)^{\gamma_n^{k,j}} \tag{2}$$

Here, $m_{n,t}^{k,j}(\omega)$ represents the quantity of intermediate composite goods from sector k used as inputs to produce $y_{n,t}^{j}(\omega)$ units of sector j variety ω, while $K_{n,t}^{j}$ and $L_{n,t}^{j}$ denote the quantities of capital and efficient labor used, respectively. The CES production function implies that $\sum_{k=1}^{J} \gamma_n^{k,j} + \gamma_n^j = 1$. Firms operate in a perfectly competitive environment and require both capital and labor as inputs. Workers supply labor directly to firms and receive a wage rate denoted by W_t. Rentiers lease their capital stock to firms and earn a rental rate denoted by R_t. Both the labor and capital markets clear in equilibrium.

Following Eaton and Kortum (2002), the productivity of good ω^j in sector j of region n is represented by $z_n^j\left(\omega^j\right)$, which is a random variable following a *Fréchet distribution*. Specifically, the distribution is given by $F_n\left(\omega^j\right) = \exp\left(-\lambda_n^j (\omega^j)^{-\theta}\right)$. The term λ_n^j governs the mean of the productivity distribution, and θ governs the variance.

The local competitive firms sell the tradable intermediate varieties globally to firms that aggregate varieties into sectoral composite goods. Specifically, the tradable sectoral intermediate varieties $r_n^j\left(\omega^j\right)$ are aggregated with constant elasticity σ into the non-tradable sectoral composite intermediate good Q_n^j through:

$$Q_n^j \equiv \left[\int_0^1 r_n^j\left(\omega^j\right)^{\frac{\sigma-1}{\sigma}}, d\omega^j\right]^{\frac{\sigma}{\sigma-1}}. \tag{3}$$

8. Also see Ahlfeldt, Redding, Sturm and Wolf (2015) and Redding (2016).

The term $r_n^j\left(\omega^j\right)$ is the quantity of variety ω^j used by country n at time t to build the sector j composite good. The term Q_n^j is the quantity of the non-tradable sectoral composite intermediate good, which is used as intermediate input or consumption.

3.2. Internal Migration and Preference

The economy consists of two types of agents: workers and rentiers. Each worker owns one unit of labor, and the mass of workers in each region m is denoted by L_m. Workers are mobile within China and face migration costs, which allow them to migrate between regions. Workers supply one unit of labor inelastically and receive income from labor.

In each region, there is a mass of one rentier who owns the capital stock in that region but cannot relocate to other regions. Rentiers lease their capital to local firms and collect rents. Both workers and rentiers consume all their income in each period and do not engage in saving or investment activities.

For each worker with a registration place in region m, the worker chooses working place n to maximize his utility, and the working place he chooses is also his living place in the model. The final utility from migration is constructed in three parts. First, through migration, the worker can get real income Λ_n in the new region, which is used to get utility from consumption, c_n. Second, there is a proportional ratio $\nu^{n,m}$ also named labor mobility costs, capturing the utility loss when people choose to migrate out of their registration place. Factors such as the physical distance, institutional costs, and amenities in the destination or source locations can influence this ratio. Third, the idiosyncratic term $z\left(\epsilon\right)$, which is a preference shifter for moving, captures the fact that the utility of people making the same migration choice (e.g., from region m to region n) is still heterogeneous across individuals.

The utility function for a worker choosing to migrate from region m to region n is given by:

$$U^{n,m} \equiv \frac{z(\epsilon)}{\nu^{n,m}} U(c_n), \quad \text{where} \quad U(c_n) \equiv c_n$$

The budget constraint in region n is:

$$\sum_{j\in\{a,m,s\}} P_n^j c_n^j = P_n^c c_n = w_n + \chi_n^w$$

Each worker is endowed with one unit of labor. For a worker registered in region m, if the worker chooses to work in region n, their Cobb-Douglas utility is expressed as:

$$1 = \sum_{j\in\{a,m,s\}} \alpha_n^j \left(c_n\right)^{\frac{(1-\sigma_c)}{\sigma_c}\varepsilon^j} \left(c_n^j\right)^{\frac{\sigma_c - 1}{\sigma_c}}$$

where $\sum_{k=1}^{J} \alpha_n^k = 1$ and P_n^k is the price of the sectoral composite intermediate good in region n for sector k, which is the same for all workers in the same region.

Income elasticities are given by:

$$\varepsilon^a < \varepsilon^m = 1 < \varepsilon^s$$

The price elasticity is:

$$0 < \sigma_c < 1$$

The aggregate price level in region n is determined by:

$$P_n = \left[\sum_{j=1}^{J} \left(\alpha_n^j\right)^{\sigma_c} \left(P_n^j\right)^{1-\sigma_c} \left(c_n\right)^{(1-\sigma_c)(\varepsilon^j - 1)} \right]^{\frac{1}{1-\sigma_c}}$$

Additionally, the expenditure share of the sectoral composite good c_n^j is given by:

$$\frac{P_n^j c_n^j}{P_n c_n} = \left(\alpha_n^j\right)^{\sigma_c} \left(\frac{P_n^j}{P_n}\right)^{1-\sigma_c} \left(c_n\right)^{(\varepsilon^j - 1)(1-\sigma_c)}$$

For each worker choosing to work in region n, their consumption of sector k's composite intermediate good is c_n^k, their aggregate consumption is c_n, and their wage rate is w_n. The number of workers in region n is L_n. The total consumption of all workers in region n is $C_n = c_n L_n$, where c_n is the consumption per worker. The workers consume the sectoral composite intermediate goods under the budget constraint:

$$\sum_k P_n^k c_n^k = P_n c_n = w_{n,t} + \chi_n^w$$

To account for observed trade imbalances, similarly in CDP, 2019, I assume both workers and rentiers send a constant share of their income, denoted by ϕ_m, to a global portfolio. In return, they receive a fixed share of the global portfolio. The distance between the income sent and the return is treated as a net transfer, generating a trade imbalance. A positive ϕ_m indicates a borrow-to-consume motivation, while a negative value implies a saving motivation.

The income transfer for workers is given by:

$$\chi_n^w = -\phi_n^w W_n + T^w \quad \text{where} \quad T^w = \frac{\sum_{n=1}^{N} \phi_n^w W_n L_n}{\sum_{n=1}^{N} L_n}$$

Similarly, the income transfer for rentiers is given by:

$$\chi_n^r = -\phi_n^r R_n + T^r \quad \text{where} \quad T^r = \frac{\sum_{n=1}^{N} \phi_n^r R_n K_n}{\sum_{n=1}^{N} K_n}$$

Thus, $D_n \equiv \chi_n^w L_n + \chi_n^r K_n$ is the trade deficit for region n.

From Equation 20 and Equation 22, the indirect utility function for an individual from region m choosing to work in region n is:

$$V(\epsilon)^{n,m} = \frac{z(\epsilon)\Lambda_n}{\nu^{n,m}}. \tag{4}$$

Real income for individuals working in region n is Λ_n, and it is defined as:

$$\Lambda_n \equiv \frac{w_n + \chi_n^w}{P_n}.$$

For each worker ϵ, the idiosyncratic preference shifter $z(\epsilon)$ is independent and identically distributed (i.i.d.) across different destination and source locations. It follows a *Fréchet distribution* with a cumulative distribution function:

$$G(z) = e^{-z^{-\kappa}},$$

where κ is the migration elasticity parameter. A large value for κ indicates a low degree of preference disparity or a higher elasticity of migration with respect to the deterministic part.

Labor Market Partial Equilibrium: Let $m^{n,m}$ denote the fraction of workers originally registered in region m who migrated to region n, where:

$$\sum_n m^{n,m} = 1.$$

From the law of large numbers, we can derive:

$$m^{n,m} = \frac{\left(\frac{\Lambda_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N0} \left(\frac{\Lambda_{n'}}{\nu^{n',m}}\right)^{\kappa}}. \tag{5}$$

Given the initial distribution of workers' registration regions, the total real income of destination regions, and the labor mobility costs $\{\bar{L}_m, \Lambda_n, \nu^{n,m}\}$, there exists a unique partial equilibrium with the labor flow share $\{m^{n,m}\}$. The total labor supply in region n can be calculated as:

$$L_n = \sum_m^{N0} m^{n,m} \bar{L}_m. \tag{6}$$

3.3. Trade, Goods Prices, and Aggregation

Trade is subject to iceberg trade costs. 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 region i, and $\kappa_{nn}^j = 1$. Adhering to the framework outlined in Eaton and Kortum (2002) and Caliendo and Parro (2015), the cost of a bundle of inputs used to produce sector j varieties for firms in region n is

$$c_n^j \equiv \Upsilon_n^j \left[(W_n)^{\beta_n^j} (R_n)^{1-\beta_n^j} \right]^{\gamma_n^j} \prod_{k=1}^{J} P_n^{k\,\gamma_n^{k,j}} \tag{7}$$

where $\Upsilon_n^j \equiv \gamma_n^j \beta_n^{j\,-\gamma_n^j \beta_n^j} \gamma_n^j \left(1-\beta_n^j\right)^{-\gamma_n^j\left(1-\beta_n^j\right)} \prod_{k=1}^{J} \gamma_n^{k,j\,-\gamma_n^{k,j}}$. The price of the sectoral composite intermediate good of sector j in region n is

$$P_n^j \equiv \left[\int_0^1 p_n^j \left(\omega^j\right)^{1-\sigma^j} d\omega^j \right]^{\frac{1}{1-\sigma^j}} = A^j \Phi_n^{j\,-\frac{1}{\theta}}, \text{ where } \Phi_n^j \equiv \sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta}. \tag{8}$$

The term $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{1-\sigma^j}}$, and $\Gamma(\cdot)$ denotes the Gamma function.

The total expenditure on the sectoral composite good j in region n is formulated as $X_n^j = P_n^j Q_n^j$. The expenditure in region n on sector j goods from region i is defined as X_{ni}^j, thus $X_n^j \equiv \sum_{m=1}^{N} X_{nm}^j$. The expenditure share of region n on sector j goods from region i is defined as $\pi_{ni}^j \equiv \frac{X_{ni}^j}{X_n^j}$, and one can derive

$$\pi_{ni}^j = \frac{\lambda_i^j \left(c_i^j \kappa_{ni}^j\right)^{-\theta}}{\sum_{m=1}^{N} \lambda_m^j \left(c_m^j \kappa_{nm}^j\right)^{-\theta}}. \tag{9}$$

The total expenditure on the sectoral composite good j in region n is the sum of the expenditure on composite intermediate goods by firms and the expenditure by workers and rentiers. Thus,

$$X_n^j = \alpha_n^j I_n + \sum_{k=1}^{J} \gamma_n^{j,k} \left(\sum_{i=1}^{N} X_{in}^k \right), \tag{10}$$

where $I_n \equiv R_n K_n + W_n L_n + D_n$ represents the total income of workers and rentiers in region n, comprising the local labor income $w_n L_n$ plus the exogenous local trade deficit D_n. $\alpha_n^j I_n$ represents the final demand for good j by workers in region n. D_n^j denotes the sectoral trade deficit, while the regional trade deficit is defined as $D_n \equiv \sum_j D_n^j$.

The trade balance condition implies $\sum_{j=1}^{J}\sum_{i=1}^{N} X_{ni}^{j} - D_n = \sum_{j=1}^{J}\sum_{i=1}^{N} X_{in}^{j}$. From the expenditure equation (29) and the trade balance condition (30), one can also derive the labor clearing condition:

$$\begin{aligned} R_n K_n &= \sum_{j=1}^{J} \left(1-\beta_n^j\right) \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j \\ W_n L_n &= \sum_{j=1}^{J} \beta_n^j \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j . \end{aligned} \tag{11}$$

3.4. Equilibrium

Given the model parameters $\left(\beta_n^j, \gamma_n^j, \gamma_n^{k,j}, \sigma_c, \epsilon^j, \sigma^j, \alpha_n^k, \phi_n^w, \phi_n^r, \theta, \kappa\right)$; sectoral productivity λ_n^j; sectoral bilateral trade costs κ_{ni}; labor mobility costs $\nu^{n,m}$; the exogenous trade deficit for all regions D_n; the exogenous capital supply for all regions K_n; the initial total population for foreign regions L_n for $n \in \mathbb{N}_1$; and the initial registered population for China's regions $\bar{L}_m$ for $m \in \mathbb{N}_0$, there exist unique values for the labor flow shares, expenditure shares, and wages $\left(\pi_{ni}^j, m^{n,m}, w_n\right)$ that satisfy the equations in Table 4.

TABLE 3
EQUILIBRIUM CONDITIONS

(F1)	$c_n^j \equiv \Upsilon_n^j \left[(W_n)^{\beta_n^j} (R_n)^{1-\beta_n^j}\right]^{\gamma_n^j} \prod_{k=1}^{J} P_n^{k\gamma_n^{k,j}}$; $\Upsilon_n^j \equiv \gamma_n^j \beta_n^{j\,-\gamma_n^j\beta_n^j} \gamma_n^j \left(1-\beta_n^j\right)^{-\gamma_n^j\left(1-\beta_n^j\right)} \prod_{k=1}^{J} \gamma_n^{k,j-\gamma_n^{k,j}}$	$\forall(n,j)$
(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)	$P_n = \left[\sum_{j=1}^{J} \left(\alpha_n^j\right)^{\sigma_c} \left(P_n^j\right)^{1-\sigma_c} (c_n)^{(1-\sigma_c)(\varepsilon^j-1)}\right]^{\frac{1}{1-\sigma_c}}$	$\forall(n)$
(H2)	$\chi_n^w = -\phi_n^w W_n + T^w \quad \text{where} \quad T^w = \frac{\sum_{n=1}^{N} \phi_n^w W_n L_n}{\sum_{n=1}^{N} L_n}$	$\forall(n)$
(H3)	$\chi_n^r = -\phi_n^r R_n + T^r \quad \text{where} \quad T^r = \frac{\sum_{n=1}^{N} \phi_n^r R_n K_n}{\sum_{n=1}^{N} K_n}$	$\forall(n)$
(H4)	$m^{n,m} = \frac{\left(\frac{\Lambda_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N0} \left(\frac{\Lambda_{n'}}{\nu^{n',m}}\right)^{\kappa}}$; $\Lambda_n \equiv \frac{w_n + \chi_n^w}{P_n}$; $L_n = \sum_{m}^{N0} m^{n,m} \bar{L}_m$	$\forall(n,m)$
(M1)	$X_n^j = \psi_n^j I_n + \sum_{k=1}^{J} \gamma_n^{j,k} \left(\sum_{i=1}^{N} X_{in}^k\right)$; $I_n \equiv R_n K_n + W_n L_n + D_n$; $D_n \equiv \chi_n^w L_n + \chi_n^r K_n$	$\forall(n,j)$
(M2)	$\psi_n^j = \left(\alpha_n^j\right)^{\sigma_c} \left(\frac{P_n^j}{P_n}\right)^{1-\sigma_c} (c_n)^{(\varepsilon^j-1)(1-\sigma_c)}$	$\forall(n,j)$
(M3)	$\sum_{j=1}^{J}\sum_{i=1}^{N} X_{ni}^j - D_n = \sum_{j=1}^{J}\sum_{i=1}^{N} X_{in}^j$	$\forall(n,j)$
(M3′)	$R_n K_n = \sum_{j=1}^{J} \left(1-\beta_n^j\right) \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j$; $W_n L_n = \sum_{j=1}^{J} \beta_n^j \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j$	$\forall(n)$

3.5. *Mechanisms*

To better understand the mechanism through which these exogenous shocks influence China's trade share of GDP, I first examine a simplified one-sector model under conditions of frictionless and balanced trade, for which I have closed-form analytical solutions for the trade share.[9] I further explore scenarios characterized by frictionless labor flow.[10] As previously noted, mainland China consists of regions indexed by $n \in \mathbb{N}_0$, while the remaining regions, indexed by $n \in \mathbb{N}_1$, represent foreign economies.

The analytical formula for China's trade share of GDP is

$$TradeShare_{CHN} = \frac{1}{\beta} \sum_{n \in \mathbb{N}_0} \psi_n \left(\sum_{i \in \mathbb{N}_1} \pi_{ni} \right), \tag{12}$$

where ψ_n is defined as the share of region n's GDP in China's GDP.[11]

Under frictionless trade, one can further derive

$$TradeShare_{CHN} = \frac{1}{\beta} \left(1 - \sum_{i \in \mathbb{N}0} \pi_{ni} \right) = \frac{1}{\beta} \left(\sum_{i \in \mathbb{N}1} \pi_{ni} \right), \tag{13}$$

and

$$\pi_{ni} = (Z_i)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}} \right]^{-1}. \tag{14}$$

The term Z_n is defined as the productive capacity of region n: $Z_n \equiv \lambda_n {L_n}^{\theta\beta}$.

Under frictionless labor flow, regional labor supply is positively related to regional TFP:

$$L_n = \frac{(\lambda_n)^{\frac{\kappa}{1+\kappa+\beta\theta}}}{\sum_{n' \in \mathbb{N}0} (\lambda_{n'})^{\frac{\kappa}{1+\kappa+\beta\theta}}} \sum_{m \in \mathbb{N}_0} \bar{L}_m. \tag{15}$$

As depicted in Equation 33, China's trade share of GDP is fundamentally influenced by expenditure shares, denoted as π_{ni}. The concept of comparative advantage (CA) and specialization is crucial for understanding China's trade share formula.

Under frictionless trade, these expenditure shares are a function of Z_i, and Z_i is defined as the productive capacity of region i: $Z_i \equiv \lambda_i {L_i}^{\theta\beta}$, where λ_i represents productivity parameters and L_i represents labor supply.

Higher productive capacity, resulting from either higher productivity or greater labor supply, allows China's regions to produce the same goods at lower production costs. Con-

9. The term "frictionless and balanced trade" refers to the situation where trade costs, denoted as κ_{ni}, are uniform at 1 for all regional pairs n and i, and every region n has a trade deficit D_n of zero.

10. Specifically, "frictionless labor flow" denotes labor mobility costs being equivalent to 1.

11. The model also implies that China's export value added to the total value added is proportional to China's trade share of GDP.

sequently, China as a whole has a comparative advantage, producing a greater variety of products compared to foreign economies and importing fewer varieties. All else being equal, this leads to an increased proportion of total spending on domestic goods, thereby decreasing the import share of GDP. Simultaneously, the export share of GDP declines despite a greater variety of exported goods, as productivity improvements lower export prices. Additionally, export trade must be balanced by import trade.

The labor supply of each of China's regions is endogenous and mainly depends on migration flows. In turn, such flows depend on the productivity of each region and labor mobility costs between China's regions.

Under frictionless labor flow, as depicted in Equation 35, labor supply depends solely on the relative size of productivity. As labor mobility frictions decrease, labor within China moves from regions with low productivity to those with high productivity. As a result, high-productivity regions produce even more varieties due to the net labor inflow, while low-TFP regions specialize in fewer varieties due to the net labor outflow. On average, the net effects depend on which channel is larger.

Two additional mechanisms are omitted when conducting an analysis based on a one-sector version of the model under free trade.

First, under multiple sectors, TFP increases in a specific sector can influence the comparative advantage of other sectors differently through input-output (IO) 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. Consequently, 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, these linkages can still lead to a significant decline in the trade share.

Second, under trade cost frictions, the mechanisms by which trade costs influence China's trade share of GDP are twofold.

On the one hand, if international import trade costs for China's regions decrease, China will produce less and source more varieties from abroad, decreasing the proportion of total spending on domestic goods and increasing the import share of GDP. Similarly, if international export trade costs for China's regions decrease, China will export more varieties of produced goods. This will increase the share of exported goods in total production, thereby raising the export share of GDP.

On the other hand, if intranational trade costs between China's regions decrease, each region in China can source a greater variety of products from other Chinese regions. As a result, fewer varieties will be sourced from abroad. This will increase the proportion of total spending on China's domestic goods and thus lead to a decreased import share of GDP.

4. Model

The model I developed is a static multi-sector, multi-region Ricardian trade model, based on the framework from Eaton and Kortum (2002) and Caliendo and Parro (2015). The model features inter-regional labor flows across China's regions, similar to Tombe and Zhu (2019).[12]The model also features input-output linkages, international trade, and inter-regional trade within China. All markets are perfectly competitive. Trade costs follow the usual iceberg form.

4.1. Production

The model consists of N_0 regions within mainland China and $N_1 = N - N_0$ foreign regions. For each region n and sector j, there is a continuum of intermediate varieties $\omega^j \in [0,1]$. The sectoral intermediate variety is tradable and is produced by local competitive firms with Cobb-Douglas technology:

$$q_n^j\left(\omega^j\right) \equiv z_n^j\left(\omega^j\right) l_n^j\left(\omega^j\right)^{\gamma_n^j} \prod_{k=1}^{J} m_n^{k,j}\left(\omega^j\right)^{\gamma_n^{k,j}}. \tag{16}$$

The term $m_n^{k,j}\left(\omega^j\right)$ is the usage of sector k's composite intermediate good in the production of region n's goods ω^j, and $\gamma_n^{k,j}$ is the corresponding share in the production function. The term $l_n^j\left(\omega^j\right)$ is the usage of labor in the production of region n's goods ω^j, and γ_n^j is the share of value added in the production. The production technology satisfies $\forall k$, $\sum_{k=1}^{J}\gamma_n^{k,j} + \gamma_n^j = 1$.

Following Eaton and Kortum (2002), the productivity of good ω^j in sector j of region n is represented by $z_n^j\left(\omega^j\right)$, which is a random variable following a *Fréchet distribution*. Specifically, the distribution is given by $F_n\left(\omega^j\right) = \exp\left(-\lambda_n^j(\omega^j)^{-\theta}\right)$. The term λ_n^j governs the mean of the productivity distribution, and θ governs the variance.

The local competitive firms sell the tradable intermediate varieties globally to firms that aggregate varieties into sectoral composite goods. Specifically, the tradable sectoral intermediate varieties $r_n^j\left(\omega^j\right)$ are aggregated with constant elasticity σ into the non-tradable sectoral composite intermediate good Q_n^j through:

$$Q_n^j \equiv \left[\int_0^1 r_n^j\left(\omega^j\right)^{\frac{\sigma-1}{\sigma}}, d\omega^j\right]^{\frac{\sigma}{\sigma-1}}. \tag{17}$$

12. Also see Ahlfeldt, Redding, Sturm and Wolf (2015) and Redding (2016).

The term $r_n^j\left(\omega^j\right)$ is the quantity of variety ω^j used by country n at time t to build the sector j composite good. The term Q_n^j is the quantity of the non-tradable sectoral composite intermediate good, which is used as intermediate input or consumption.

4.2. Internal Migration and Preference

For each worker with a registered place in region m of China, the worker can migrate to another region n within China to maximize their utility. The utility for a worker migrating from m to n is:

$$U^{n,m} \equiv \frac{z(\epsilon)}{\nu^{n,m}} U_n. \tag{18}$$

This utility is constructed from three parts. First, through migration, the worker can earn income $\mathcal{I}_n$ in the new region, which can be used to derive utility U_n from consumption. Second, there is a proportional ratio $\nu^{n,m}$, also known as labor mobility costs, which captures the utility loss when individuals migrate out of their registration place. Factors such as physical distance, institutional costs, and the amenities of the destination or source locations can influence this ratio. Third, the idiosyncratic term $z(\epsilon)$, which is a random variable with a mean invariant to the source or destination location. This term is defined as the preference shifter for moving. It captures the fact that the utility of individuals making the same migration choice (e.g., from region m to region n) is still heterogeneous across individuals. Specifically, for each worker ϵ, the idiosyncratic preference shifter $z(\epsilon)$ follows a *Fréchet distribution* with a cumulative distribution function[13]:

$$z(\epsilon) \sim G(z) = e^{-z^{-\kappa}}. \tag{19}$$

Specifically, for each worker migrating to region n, the utility from consumption is defined as:

$$U_n \equiv \prod_{j=1}^{J} (\mathcal{C}_n^j)^{\alpha_n^j}, \text{ where } \sum_{j=1}^{J} \alpha_n^j = 1. \tag{20}$$

The consumption price index of region n is given by:

$$P_n = \prod_{j=1}^{J} \left(\frac{P_n^j}{\alpha_n^j}\right)^{\alpha_n^j}. \tag{21}$$

Each worker purchases and consumes sectoral composite intermediate goods $\mathcal{C}_n^j$ with price P_n^j under the budget constraint:

13. The term κ is defined as the migration elasticity parameter. A large value for κ means a low degree of preference disparity or a higher elasticity of migration with respect to the deterministic part.

$$\sum_j P_n^j \mathcal{C}_n^j = \mathcal{I}_n, \text{ where } \mathcal{I}_n = w_n + \frac{D_n}{L_n}. \tag{22}$$

The term $\mathcal{I}_n$ is the income per worker, which is derived from two sources: each worker supplies one unit of labor, earning a wage w_n, and receives lump-sum transfers (trade deficits, D_n), which are equally distributed across local workers. The number of workers in region n is L_n. Therefore, the total consumption of sectoral composite goods j by all workers in region n is $C_n^j = \mathcal{C}_n^j L_n$. The total income for all workers in region n is $I_n = \mathcal{I}_n L_n$.

From Equation 20 and Equation 22, the indirect utility function for an individual from region m choosing to work in region n is:

$$V(\epsilon)^{n,m} = \frac{z(\epsilon) W_n}{\nu^{n,m}}, \tag{23}$$

where $W_n \equiv \dfrac{\mathcal{I}_n}{P_n}$ is defined as the real income for each worker in region n.

Let $m^{n,m}$ denote the fraction of workers registered in region m who migrated to region n, where $\sum_n m^{n,m} = 1$. From the law of large numbers, one can derive[14]:

$$m^{n,m} = \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}}. \tag{24}$$

The total labor supply in region n is:

$$L_n = \sum_m^{N_0} m^{n,m} \bar{L}_m. \tag{25}$$

4.3. Trade, Goods Prices, and Aggregation

Trade is subject to iceberg trade costs. 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 region i, and $\kappa_{nn}^j = 1$. Adhering to the framework outlined in Eaton and Kortum (2002) and Caliendo and Parro (2015), the cost of a bundle of inputs used to produce sector j varieties for firms in region n is

$$c_n^j = \Upsilon_n^j {w_n}^{\gamma_n^j} \prod_{k=1}^{J} {P_n^k}^{\gamma_n^{k,j}}, \text{ where } \Upsilon_n^j \equiv \prod_{k=1}^{J} {\gamma_n^{k,j}}^{-\gamma_n^{k,j}} {\gamma_n^j}^{-\gamma_n^j}. \tag{26}$$

The price of the sectoral composite intermediate good of sector j in region n is

$$P_n^j \equiv \left[\int_0^1 p_n^j \left(\omega^j\right)^{1-\sigma^j} d\omega^j\right]^{\frac{1}{1-\sigma^j}} = A^j {\Phi_n^j}^{-\frac{1}{\theta}}, \text{ where } \Phi_n^j \equiv \sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta}. \tag{27}$$

14. See Appendix B for derivation details.

The term $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{1-\sigma^j}}$, and $\Gamma(\cdot)$ denotes the Gamma function.

The total expenditure on the sectoral composite good j in region n is formulated as $X_n^j = P_n^j Q_n^j$. The expenditure in region n on sector j goods from region i is defined as X_{ni}^j, thus $X_n^j \equiv \sum_{m=1}^{N} X_{nm}^j$. The expenditure share of region n on sector j goods from region i is defined as $\pi_{ni}^j \equiv \frac{X_{ni}^j}{X_n^j}$, and one can derive

$$\pi_{ni}^j = \frac{\lambda_i^j \left(c_i^j \kappa_{ni}^j\right)^{-\theta}}{\sum_{m=1}^{N} \lambda_m^j \left(c_m^j \kappa_{nm}^j\right)^{-\theta}}. \tag{28}$$

The total expenditure on the sectoral composite good j in region n is the sum of the expenditure on composite intermediate goods by firms and the expenditure by households. Thus,

$$X_n^j = \alpha_n^j I_n + \sum_{k=1}^{J} \gamma_n^{j,k} \left(\sum_{i=1}^{N} X_{in}^k\right), \tag{29}$$

where $I_n \equiv w_n L_n + D_n$ represents the total income of workers in region n, comprising the local labor income $w_n L_n$ plus the exogenous local trade deficit D_n. $\alpha_n^j I_n$ represents the final demand for good j by workers in region n. D_n^j denotes the sectoral trade deficit, while the regional trade deficit is defined as $D_n \equiv \sum_j D_n^j$.

The trade balance condition implies

$$\sum_{j=1}^{J} \sum_{i=1}^{N} X_{ni}^j - D_n = \sum_{j=1}^{J} \sum_{i=1}^{N} X_{in}^j. \tag{30}$$

From the expenditure equation (29) and the trade balance condition (30), one can also derive the labor clearing condition:

$$w_n L_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j. \tag{31}$$

4.4. Equilibrium

Given the model parameters $\left(\gamma_n^j, \gamma_n^{k,j}, \sigma^j, \alpha_n^k, \theta, \kappa\right)$; sectoral productivity λ_n^j; sectoral bilateral trade costs κ_{ni}; labor mobility costs $\nu^{n,m}$; the exogenous trade deficit for all regions D_n; the initial total population for foreign regions L_n for $n \in \mathbb{N}_1$; and the initial registered population for China's regions $\bar{L}_m$ for $m \in \mathbb{N}_0$, there exist unique values for the labor flow shares, expenditure shares, and wages $\left(\pi_{ni}^j, m^{n,m}, w_n\right)$ that satisfy the equations in Table 4.

TABLE 4
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)	$P_n^j = A^j (\sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta})^{-\frac{1}{\theta}}$; $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{(1-\sigma^j)}}$	$\forall(n,j)$
(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′)	$w_n L_n = \sum_{j=1}^{J} \gamma_n^j \sum_{i=1}^{N} \pi_{in}^j X_i^j$	$\forall(n)$

4.5. Mechanisms

To better understand the mechanism through which these exogenous shocks influence China's trade share of GDP, I first examine a simplified one-sector model under conditions of frictionless and balanced trade, for which I have closed-form analytical solutions for the trade share.[15] I further explore scenarios characterized by frictionless labor flow.[16] As previously noted, mainland China consists of regions indexed by $n \in \mathbb{N}_0$, while the remaining regions, indexed by $n \in \mathbb{N}_1$, represent foreign economies.

The analytical formula for China's trade share of GDP is

$$TradeShare_{CHN} = \frac{1}{\beta} \sum_{n \in \mathbb{N}_0} \psi_n \left(\sum_{i \in \mathbb{N}_1} \pi_{ni} \right), \tag{32}$$

where ψ_n is defined as the share of region n's GDP in China's GDP.[17]

15. The term "frictionless and balanced trade" refers to the situation where trade costs, denoted as κ_{ni}, are uniform at 1 for all regional pairs n and i, and every region n has a trade deficit D_n of zero.
16. Specifically, "frictionless labor flow" denotes labor mobility costs being equivalent to 1.
17. The model also implies that China's export value added to the total value added is proportional to China's trade share of GDP.

Under frictionless trade, one can further derive

$$TradeShare_{CHN} = \frac{1}{\beta}\left(1 - \sum_{i\in\mathbb{N}0} \pi_{ni}\right) = \frac{1}{\beta}\left(\sum_{i\in\mathbb{N}1} \pi_{ni}\right), \tag{33}$$

and

$$\pi_{ni} = (Z_i)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{-1}. \tag{34}$$

The term Z_n is defined as the productive capacity of region n: $Z_n \equiv \lambda_n {L_n}^{\theta\beta}$.

Under frictionless labor flow, regional labor supply is positively related to regional TFP:

$$L_n = \frac{(\lambda_n)^{\frac{\kappa}{1+\kappa+\beta\theta}}}{\sum_{n'\in\mathbb{N}0} (\lambda_{n'})^{\frac{\kappa}{1+\kappa+\beta\theta}}} \sum_{m\in\mathbb{N}_0} \bar{L}_m. \tag{35}$$

As depicted in Equation 33, China's trade share of GDP is fundamentally influenced by expenditure shares, denoted as π_{ni}. The concept of comparative advantage (CA) and specialization is crucial for understanding China's trade share formula.

Under frictionless trade, these expenditure shares are a function of Z_i, and Z_i is defined as the productive capacity of region i: $Z_i \equiv \lambda_i {L_i}^{\theta\beta}$, where λ_i represents productivity parameters and L_i represents labor supply.

Higher productive capacity, resulting from either higher productivity or greater labor supply, allows China's regions to produce the same goods at lower production costs. Consequently, China as a whole has a comparative advantage, producing a greater variety of products compared to foreign economies and importing fewer varieties. All else being equal, this leads to an increased proportion of total spending on domestic goods, thereby decreasing the import share of GDP. Simultaneously, the export share of GDP declines despite a greater variety of exported goods, as productivity improvements lower export prices. Additionally, export trade must be balanced by import trade.

The labor supply of each of China's regions is endogenous and mainly depends on migration flows. In turn, such flows depend on the productivity of each region and labor mobility costs between China's regions.

Under frictionless labor flow, as depicted in Equation 35, labor supply depends solely on the relative size of productivity. As labor mobility frictions decrease, labor within China moves from regions with low productivity to those with high productivity. As a result, high-productivity regions produce even more varieties due to the net labor inflow, while low-TFP regions specialize in fewer varieties due to the net labor outflow. On average, the net effects depend on which channel is larger.

Two additional mechanisms are omitted when conducting an analysis based on a one-sector version of the model under free trade.

First, under multiple sectors, TFP increases in a specific sector can influence the comparative advantage of other sectors differently through input-output (IO) 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. Consequently, 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, these linkages can still lead to a significant decline in the trade share.

Second, under trade cost frictions, the mechanisms by which trade costs influence China's trade share of GDP are twofold.

On the one hand, if international import trade costs for China's regions decrease, China will produce less and source more varieties from abroad, decreasing the proportion of total spending on domestic goods and increasing the import share of GDP. Similarly, if international export trade costs for China's regions decrease, China will export more varieties of produced goods. This will increase the share of exported goods in total production, thereby raising the export share of GDP.

On the other hand, if intranational trade costs between China's regions decrease, each region in China can source a greater variety of products from other Chinese regions. As a result, fewer varieties will be sourced from abroad. This will increase the proportion of total spending on China's domestic goods and thus lead to a decreased import share of GDP.

5. Calibration

In this section, I calibrate the model, which will then be used to quantify the forces driving changes in China's trade share of GDP over time. The paper encompasses eight regions in mainland China, three foreign economic groups, and four sectors over the periods 2002–2007 and 2007–2015. The eight regions within mainland China include A. Northeast, B. Beijing and Tianjin, C. Northern Coastal, D. Eastern Coastal, E. Southern Coastal, F. Central, G. Northwest, and H. Southwest (see Figure 2). The three foreign economic groups include an aggregate of Japan, Korea, and Taiwan ("Asian3"); G7 countries excluding Japan ("G6"); and an aggregate of the remaining economies, treated as the rest of the world ("ROW"). The sectors comprise agriculture, light industry, heavy industry, and services. Table 5 displays an overview of the calibration.

Figure 2
China's Regions

TABLE 5
Calibration

Time-Invariant Parameters	Index	Methodology
Trade elasticity	$\theta = 4$	Simonovska and Waugh (2014)
Labor flow elasticity	$\kappa = 1.5$	Tombe and Zhu (2019)
Intermediate varieties elasticity	$\sigma^j = 2$	Broda and Weinstein (2006)
Expenditure share	α_n^j	IO table
Production share	$\gamma_n^j, \gamma_n^{j,k}$	IO table
Time-Varying Shocks		
Productivity	λ_n^j	Gravity equation and calculation
Trade cost	κ_{ni}^j	Gravity equation and calculation
Labor mobility cost	ν_{nm}	Gravity equation and calculation
Labor supply	$\bar{L}^m$	PWT 10.01; China Census data

The data used in this paper are sourced from the 5th National Census of China (2000), the 6th National Census of China (2005), and the 7th National Census of China (2015); the Penn World Table (PWT) 10.0 for the years 2002, 2007, and 2015 (Feenstra, Inklaar, and Timmer, 2015); the World Input-Output Database: Socio-Economic Accounts; the World Input-Output Table (WIOD) for 2002 and 2007 (Timmer, Dietzenbacher, Los, Stehrer, and de Vries, 2015); the OECD Inter-Country Input-Output (ICIO) Tables for 2015 (OECD, 2021); the China Cross Regional Input-Output Table for 2002, 2007, and 2015 (Zhang and Qi, 2012; Zheng, Zhang, Wei, Song, Dietzenbacher, Wang, Meng, Shan, Ou, and Guan, 2020); and the CEPII database (Head and Mayer, 2014). Additionally, I constructed a multi-region, multi-sector input-output table by combining the China IO table with the World IO tables (2002 and 2007 WIOD tables and the 2015 OECD IO table). This constructed IO table, as aforementioned, includes eleven regions, comprising eight regions within mainland China, three foreign economy groups, and four sectors. For detailed information regarding data sources, selected countries, sector concordance across various sources, and the procedures used in constructing the inter-region input-output table, please refer to Appendix E.

5.1. *Time-Invariant Parameters*

In this section, I calculate the exogenous, time-invariant parameters. Specifically, the model allows for the derivation of the production share parameters as follows:

$$\gamma_n^j = \frac{V_n^j}{Y_n^j}, \text{ and } \gamma_n^{j,k} = (1-\gamma_n^j)\frac{V_n^{j,k}}{\sum_{j=1}^J V_n^{j,k}}. \tag{36}$$

The expenditure share parameters, denoted by α_n^j, can be derived using:

$$\alpha_n^j = \frac{Y_n^j + D_n^j - \sum_{k=1}^J \gamma_n^{j,k} Y_n^k}{I_n}, \text{ where } I_n = w_n L_n + D_n. \tag{37}$$

Here, $Y_n^j = \sum_{i=1}^N X_{in}^j$ represents the gross production value of sector j goods in region n. V_n^j denotes the value added by region n from sector j. $V_n^{j,k}$ is the value of demand for sector j goods in the production of sector k goods in region n. D_n^j signifies the trade deficit for sector j in region n, and D_n represents the total trade deficit for region n, given by $D_n = \sum_{j=1}^J D_n^j$. These data are obtained from the multi-region, multi-sector input-output table.

These production and expenditure shares are assumed to be time-invariant. Consequently, I average these parameters over three years to establish a time-invariant fundamental. Additionally, following Simonovska and Waugh (2014), I set the trade elasticity parameter θ to 4. Based on Tombe and Zhu (2019), I set the labor flow elasticity parameter κ to 1.5. The elasticity of substitution among intermediate goods within a sector is assumed to be constant across all sectors, with $\sigma^j = 2$ for all j (Broda and Weinstein, 2006), and the outcomes remain unaffected by this specific parameter selection.

5.2. *Time-Varying Shocks*

In this section, I calibrate the time-varying shocks using data from various databases, the calibrated time-invariant parameters, the estimated fixed effects from the gravity equation regression, and the relationships implied by the model.

From Equation 28, I derive the following structural gravity equation:

$$\ln\left(\frac{X^j_{ni,t}}{X^j_{nn,t}}\right) = \ln\left(\lambda^j_{i,t}\left(c^j_{i,t}\right)^{-\theta}\right) - \ln\left(\lambda^j_{n,t}\left(c^j_{n,t}\right)^{-\theta}\right) - \theta\ln\left(\kappa^j_{ni,t}\right). \tag{38}$$

Following Eaton and Kortum (2002), I assume that the unobserved trade cost terms $\kappa^j_{ni,t}$ can be described by both a symmetric component and an exporter-specific component.[18] The symmetric component is well proxied by geographic distance:

$$\log\left(\kappa^j_{ni,t}\right) = EX^j_{i,t} + \beta^j_t \log\left(Dist_{ni}\right) + \epsilon^j_{ni,t}, \tag{39}$$

where t is a time variable. $EX^j_{n,t}$ is exporter n's fixed effect in the regression fixed at sector j and time t. $X^j_{ni,t}$ denotes the value of sector j goods imported by region n from region i. This data is derived from the constructed multi-region, multi-sector input-output table. The term $\log\left(Dist_{ni}\right)$ is the logarithm of the population-weighted geographic distance between regions n and i, defined as follows:

$$Dist_{ni} = \sum_{r\in\{r^n_1,\dots,r^n_p\}}\left(\frac{pop_r}{pop_n}\sum_{s\in\{r^i_1,\dots,r^i_q\}}\left(\frac{pop_s}{pop_i}\right)Dist_{rs}\right), \tag{40}$$

where pop_n represents the population of economic group (or China's region) n. Each economic group (or China's region) n comprises a set of economies (or China's provinces), denoted as $\{r^n_1,\dots,r^n_p\}$.

To calculate the population-weighted geographic distance, I first record the coordinate data of the capitals of each of mainland China's 34 provinces and the capitals 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, consisting of 8 regions in China (each corresponding to an aggregation of several of China's provinces) and 3 groups of foreign economies (each group including an aggregation of several foreign economies). For the population-based weights, I use population data from the year 2000, sourced from the China Statistical Yearbook and the Penn World Table version 10.

Combining Equation 39 and Equation 38, I get the following structural equation:

$$\log\left(\frac{X^j_{ni,t}}{X^j_{nn,t}}\right) = E^j_{i,t} + M^j_{n,t} + \Theta^j_t \log Dist_{ni} + \nu^j_{ni,t}, \tag{41}$$

where $E^j_{i,t} \equiv S^j_{i,t} - \theta EX^j_{i,t}$, $M^j_{n,t} \equiv -S^j_{n,t}$, $\Theta^j_t \equiv -\theta\beta^j_t$, $\nu^j_{ni,t} \equiv -\theta\epsilon^j_{ni,t}$, and $S^j_{n,t} \equiv \log\left(\lambda^j_{n,t}\left(c^j_{n,t}\right)^{-\theta}\right)$. The following steps are implemented to calibrate each of these exogenous shocks.

18. See also Waugh (2010), Levchenko and Zhang (2016), Tombe and Zhu (2019), and Santacreu, Sposi and Zhang (2023)

Estimate $\tilde{M}^j_{n,t}$ I estimate the imported fixed effects $\tilde{M}^j_{n,t}$ by running the regression outlined in Equation 41 separately for each year and sector. For details of the regression results, please refer to Table D.1 in Appendix D.

Calibrate Trade Cost The term $S^j_{n,t}$ represents the technology states for region n, sector j, at time t. Based on the estimated values of $\tilde{M}^j_{n,t}$, the technology states, $S^j_{n,t}$, are given by $S^j_{n,t} = -\tilde{M}^j_{n,t}$. The degrees of freedom imply that $M^j_{n,t}$ is identified only up to a normalization within each sector. I use the region AS3 (an aggregation of Japan, Korea, and Taiwan) as the reference location, so $\tilde{M}^j_{AS3,t} = 0$. Since the fixed effects ($\tilde{M}^j_{n,t}$) I estimate are relative to the reference location's fixed effects, for each year and sector, I have $S^j_{n,t} - S^j_{AS3,t} = -\tilde{M}^j_{n,t}$.

From Equation 38, the trade cost can be derived as follows:

$$\kappa^j_{ni,t} = \left(\frac{X^j_{ni,t}}{X^j_{nn,t}}\right) \exp\left(S^j_{n,t} - S^j_{i,t}\right)^{-\frac{1}{\theta}} = \left(\frac{X^j_{ni,t}}{X^j_{nn,t}}\right) \exp\left(\tilde{M}^j_{i,t} - \tilde{M}^j_{n,t}\right)^{-\frac{1}{\theta}}. \tag{42}$$

Calibrate Productivity Equation 27 and Equation 28 indicate that:

$$P^j_{n,t} = A^j \left(\frac{\exp(S^j_{n,t})}{\pi^j_{nn,t}}\right)^{-\frac{1}{\theta}}. \tag{43}$$

Thus, given the sectoral price for the region AS3, the technology term for this region can be derived as:

$$S^j_{n,t} = \log\left[\pi^j_{nn,t} \cdot \left(\frac{P^j_{n,t}}{A^j}\right)^{-\theta}\right], \text{ for } n = \text{AS3}. \tag{44}$$

The technology term for other regions can be calculated as:

$$S^j_{n,t} = S^j_{AS3,t} - \tilde{M}^j_{n,t}, \text{ for } n \neq \text{AS3}. \tag{45}$$

Given the value of the term $S^j_{n,t}$, the sectoral price $P^j_{n,t}$ for regions other than AS3 can be imputed using Equation 43. From $S^j_{n,t} \equiv \ln\left(\lambda^j_{n,t}\left(c^j_{n,t}\right)^{-\theta}\right)$, the productivity term $\lambda^j_{n,t}$ can be derived as follows:

$$\lambda^j_{n,t} = \frac{\exp\left(S^j_{n,t}\right)}{\left(c^j_{n,t}\right)^{-\theta}}. \tag{46}$$

Here, $c^j_{n,t} = \Upsilon^j_n w^{\gamma^j_n}_{n,t} \prod_{k=1}^{J} {P^k_{n,t}}^{\gamma^{k,j}_n}$, where $\Upsilon^j_n \equiv \prod_{k=1}^{J} \gamma^{k,j}_n \left(\gamma^j_n\right)^{-\gamma^j_n}$.[19]

19. Sectoral intermediate price data for region AS3 are sourced from the WIOD Socio-Economic Accounts

Calibrate Labor Mobility Cost From Equation 24, the labor mobility cost is calculated as:

$$\nu_t^{n,m} = \left(\frac{m_t^{n,m}}{m_t^{m,m}}\right)^{-1/\kappa} \left(\frac{W_{n,t}}{W_{m,t}}\right). \tag{47}$$

Here, $m_t^{n,m}$ represents the share of workers registered in region m who migrate to region n. The real income per worker in region n is given by $W_{n,t} = \dfrac{w_{n,t}L_{n,t} + D_{n,t}}{P_{n,t}L_{n,t}}$, where $w_{n,t}L_{n,t}$ denotes the local value-added, and $D_{n,t}$ denotes the exogenous trade deficit. The price level of aggregate consumption in region n, $P_{n,t}$, is derived from:

$$P_{n,t} = \prod_{j=1}^{J} \left(\frac{P_{n,t}^j}{\alpha_n^j}\right)^{\alpha_n^j}. \tag{48}$$

Specifically, the value-added and trade deficit data are get from the constructed IO table. The country-level total labor force data are sourced from PWT 10.01, which reports the number of persons engaged (in millions) at the year and country levels. Data on China's cross-region labor flow share and labor distribution across source locations are calculated from surveys reported in the China Population Census (2000) and the China Population 1% Sampling Survey (2005, 2015).[20] Since there are no relevant data for the years 2002 and 2007, data from 2000 and 2005 are used as approximations for 2002 and 2007.

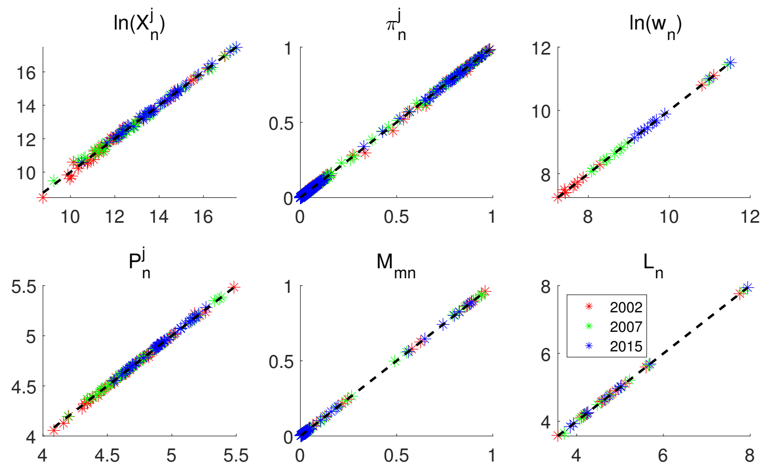
5.3. *Model Fit*

In this section, I reintroduce both the calibrated time-invariant parameters and the time-varying shocks into the model to assess the accuracy of the calibration.

Figure 3 displays a comparison between model-generated values (on the y-axis) and real-world values (on the x-axis). The data points include the logarithmic values of expenditures X_{ni}^j, expenditure shares π_{ni}^j, logarithmic wages w_n, prices P_n^j, migration shares M_{mn}, and labor supplies L_n for each of the 11 regions. The correlation between the model-generated data and the real-world data aligns closely with the 45-degree line, demonstrating that the calibrated shocks accurately replicate real-world observations.

Database. Further details are provided in Appendix E.

20. The official reports of these surveys are report in two versions: one reports micro inidividual level data, which is confidential, and the other reports data at the macro province level. The provincial-level reports detail the number of people currently living in province A but registered in province B. For this paper, due to data availability, I use the provincial-level data to calculate China's labor flow share and labor distribution across source locations at the regional level.



Note: The scatter plots display real data on the x-axis and model-generated values on the y-axis, with a 45-degree reference line on the diagonal.

Figure 3
Calibration Efficiency

5.4. Discussion

This section presents and discusses each of these calibrated time-varying shocks.

TABLE 6
Average productivity (${\lambda_n^j}^{1/\theta}$) changes

Average Productivity Change (%)	**2002 to 2007** China	G6	AS3	ROW	**2007 to 2015** China	G6	AS3	ROW
Total	32.2	22.6	3.1	51.7	51.9	16.0	-6.0	37.9
Agriculture	39.6	26.7	9.9	63.4	44.0	-14.7	-3.2	10.1
Light Industry	22.4	4.3	5.7	21.5	22.6	-4.7	-13.0	-7.3
Heavy Industry	20.9	13.7	-0.3	28.1	31.1	-6.5	-6.4	-8.1
Services	39.7	24.9	3.9	60.3	71.8	21.5	-5.6	58.7

Notes: This table presents the average percentage changes in productivity relative to the base year for the periods 2002–2007 and 2007–2015. Regional sectoral productivity is aggregated using average value-added shares (averaged over the years 2002, 2007, and 2015) as weights, ensuring that variations in average productivity are not attributable to shifts in value-added structures. For further details on the time-series changes in calibrated productivity (${\lambda_n^j}^{1/\theta}$), refer to Appendix D.

Productivity shocks Table 6 presents the average changes in productivity across sectors and regions. Overall, China experienced an average productivity growth rate of 32.2% from 2002 to 2007, which increased to 51.9% from 2007 to 2015. At the sector level, growth rates from 2007 to 2015 exceeded those from 2002 to 2007 in all sectors, with the services sector growing the most, achieving a 71.8% growth rate in the latter period. Compared to other economic groups, it is evident that China's growth stands out significantly in both periods.

TABLE 7
AVERAGE TRADE COST CHANGES

Average Trade Cost Change (%)	China to Foreign (Export) 2002 to 2007	China to Foreign (Export) 2007 to 2015	Foreign to China (Import) 2002 to 2007	Foreign to China (Import) 2007 to 2015
Total	-22.6	-23.4	-0.9	15.1
Agriculture	-26.8	-30.5	4.5	54.4
Light Industry	-20.1	-24.2	15.5	31.0
Heavy Industry	-23.7	-11.5	-2.9	12.3
Services	-22.4	-43.0	-0.4	15.2
	China and China		**Foreign and Foreign**	
	2002 to 2007	**2007 to 2015**	**2002 to 2007**	**2007 to 2015**
Total	-12.0	-1.2	-4.2	-6.8
Agriculture	-15.0	-2.4	-2.3	9.6
Light Industry	-7.9	6.2	2.8	5.3
Heavy Industry	-9.5	6.2	-2.5	-0.4
Services	-17.0	-14.7	-7.3	-17.2

Notes: This table shows the percentage changes in average trade costs relative to the base year for the periods 2002–2007 and 2007–2015. Regional sectoral trade costs are aggregated using the average expenditure shares (averaged over the years 2002, 2007, and 2015) as weights. This approach ensures that changes in trade costs are not attributed to variations in expenditure structures. For detailed information on the calibrated sectoral trade cost changes over time, refer to Appendix D.

Trade cost shocks Table 7 presents the average changes in trade costs across sectors and regions. From 2002 to 2007, China experienced a uniform decline in intranational trade costs across all sectors. However, reductions in trade costs with foreign regions were observed only in exports across all sectors, with minimal overall decline in imports. The decline in trade costs for both export and intranational trade can be attributed to China's accession to the WTO in 2001, as well as the country's continuous development and integration of its domestic market.

From 2007 to 2015, China's average internal trade costs showed minimal reduction. However, its export trade costs decreased by 23.4%, slightly higher than the previous period's decline of 22.6%. Conversely, the average import trade cost increased.

Labor mobility cost shocks Table 8 illustrates changes in labor mobility costs over two periods. At the aggregate level, there was an average decrease of 13.3% in labor mobility costs from 2002 to 2007, followed by a similar decrease of 11.8% from 2007 to 2015. These changes reflect the government's gradual loosening of regulations concerning internal labor flows. One explanation for the slower decline in the latter period is that from 2007 to 2015, local governments in China gradually relaxed regulations on changing the registration province. Consequently, it became easier to change one's registration place compared to the previous period. Although registration-based labor mobility costs cannot directly capture

TABLE 8
Labor mobility cost changes

2002 to 2007	Source								
Destination	Ave.	NE	BT	NC	EC	SC	CE	NW	SW
Aggregate (Ave.)	-13.3	-17.3	-8.2	-30.8	32.2	9.9	-28.6	-2.2	-29.3
NorthEast (NE)	-5.1	-	-21.6	-17.0	42.5	1.8	-17.6	-10.7	-3.7
BeijingTianjin (BT)	-35.1	-45.3	-	-40.5	-4.9	-14.7	-41.9	-29.9	-46.3
NorthernCoastal (NC)	17.9	3.9	1.6	-	53.5	45.6	5.9	25.8	1.7
EasternCoastal (EC)	-42.3	-44.2	-37.1	-53.7	-	-22.2	-43.9	-33.5	-52.9
SouthernCoastal (SC)	-25.5	-27.2	-16.6	-37.9	12.3	-	-28.7	-17.4	-30.0
Central (CE)	26.7	9.4	13.7	9.5	43.8	33.5	-	57.7	8.2
NorthWest (NW)	-8.6	23.7	-3.8	-18.9	28.2	-9.8	-24.4	-	-15.0
SouthWest (SW)	29.8	26.9	-0.5	-4.4	48.5	50.1	-0.7	52.6	-
2007 to 2015	**Source**								
Destination	Ave.	NE	BT	NC	EC	SC	CE	NW	SW
Aggregate (Ave.)	-11.8	-40.8	-51.2	6.9	8.5	-51.6	25.5	-27.1	15.4
NorthEast (NE)	35.3	-	-46.8	94.0	70.1	-10.1	75.1	26.4	18.7
BeijingTianjin (BT)	0.1	-34.1	-	11.4	37.2	-29.0	24.0	-22.8	16.7
NorthernCoastal (NC)	-21.1	-26.9	-39.5	-	1.4	-57.6	-6.2	-28.1	6.4
EasternCoastal (EC)	-27.6	-57.4	-57.4	-27.4	-	-50.1	-3.8	-56.0	-7.9
SouthernCoastal (SC)	70.7	-16.8	-10.2	80.1	79.7	-	107.5	34.6	71.1
Central (CE)	-48.3	-62.5	-76.6	-29.5	-41.4	-69.1	-	-41.7	-20.9
NorthWest (NW)	19.8	-33.5	-52.1	17.3	45.1	-38.5	53.2	-	74.2
SouthWest (SW)	-37.4	-61.8	-43.1	-29.1	-22.1	-59.8	7.8	-44.2	-

Notes: This table displays the percentage changes in labor mobility costs relative to the base year for the periods 2002–2007 and 2007–2015. Migration frictions are aggregated using average labor flow shares, weighted by the years 2000, 2005, and 2015 due to data availability. This method ensures that changes in migration frictions are not influenced by variations in labor flow shares. For further details on the calibrated migration cost changes over time, see Appendix D.

the population that changed its registration province, they can still be indirectly reflected by the initial change in labor supply in the region. Therefore, when conducting counterfactual analysis, I assess both the effects of the change in labor mobility costs and the initial change in labor supply.

Summary Overall, The behavior of these calibrated time-varying shocks aligns with intuition. A complete story explaining and quantifying the effects of each shock requires further counterfactual analysis.

6. Quantitative Analysis

In this section, I perform structural accounting decompositions to quantify the effects of various forces on changes in China's trade share. I categorize these time-varying shocks into several types: China's sectoral productivity shocks, China's regional initial labor supply shocks, China's labor mobility cost shocks, China's intranational trade cost shocks, China's international trade cost shocks, and shocks from other regions. The latter category encompasses shocks to foreign economies' sectoral productivity, foreign economies' labor supply, and trade costs between foreign economies.

Although the primary focus of the paper is to quantify the forces driving changes in China's trade share of GDP, I also examine the impacts on other macroeconomic variables, such as China's intranational trade share of GDP and real income per worker.

Specifically, I perform structural accounting decompositions as follows: For each shock type, I solve the model with that specific shock held at the base-year level, while allowing all other shocks to vary as observed. I then compare this outcome with the baseline scenario. The baseline scenario represents the condition where all shocks occur as observed. The marginal effects of each specific shock are calculated as the difference between the values under the baseline scenario and the scenario where the specific shock is unchanged. This method enables the quantification of changes in China's trade share of GDP attributable to specific forces. Additionally, I conduct structural accounting decompositions for some types of forces (e.g., changes in China's productivity, changes in international trade costs) at a more disaggregated level (e.g., sector level), and interact some types of forces at a more aggregated level in a similar manner.

TABLE 9
MODEL FIT

China Trade (% of GDP)	**Year**	**Data**	**Model**	
			Trade balance	Exogenous trade deficits
			Basline 1	Basline 2
Import	**2002**	19.7	23.3	20.9
	2007	26.0	28.5	24.0
	2015	17.4	19.1	17.6
Export	**2002**	23.5	-	24.8
	2007	36.7	-	34.7
	2015	20.0	-	20.2
Internal trade	**2002**	28.0	27.5	29.8
	2007	48.6	43.8	46.1
	2015	48.3	47.1	48.0

Table 9 presents both real data and model-generated data under different trade balance assumptions (Baseline 1 and 2). The baseline results effectively replicate real-world data, particularly under the exogenous trade deficit assumption (Baseline 2). Specifically, I address trade deficits in two distinct ways when conducting counterfactual analyses. In the main text, Baseline 1 serves as the reference, and counterfactuals are analyzed under balanced trade conditions. In Appendix F, I perform robustness checks using Baseline 2 as the reference, conducting similar counterfactual analyses with the model solved under an exogenous trade deficit to GDP ratio.[21] The conclusions from these robustness checks align with those in the main text.

6.1. Decomposition of Change in Trade Share of GDP

TABLE 10
STRUCTURAL ACCOUNTING DECOMPOSITION

Marginal effects	**2002 to 2007**			**2007 to 2015**		
	Trade Share of GDP change (p.p.)		Real GDP p.c. change (%)	Trade Share of GDP change (p.p.)		Real GDP p.c. change (%)
	International	Intranational		International	Intranational	
All forces (Baseline)	**5.2**	**16.3**	**123.4**	**-9.4**	**3.3**	**164.5**
China's productivity	**-8.4**	**3.8**	**102.1**	**-12.5**	**0.3**	**148.2**
China's labor	**0.5**	**-1.5**	**2.5**	**-1.4**	**1.2**	**4.5**
Labor mobility cost	0.8	-1.6	3.0	-1.0	1.2	4.4
labor supply	-0.3	0.1	-0.4	-0.4	0.0	0.2
China's trade cost	**5.3**	**12.7**	**6.6**	**-3.2**	**-4.8**	**-2.1**
Intranational	-1.2	14.3	4.0	0.0	-4.0	-1.5
International	6.8	-1.6	2.7	-3.6	-1.2	-1.0
Other regions' forces	**4.9**	**-0.5**	**1.4**	**-0.8**	**2.4**	**-0.7**
Foreign productivity	4.7	-0.5	1.4	-0.4	2.2	-0.5
Foreign trade cost	-0.4	0.2	-0.2	-0.7	0.2	-0.2
Foreign labor	0.7	-0.1	0.2	0.5	-0.1	0.1

Notes: This table decomposes changes in international and intranational trade shares of GDP, as well as real GDP per worker, into contributions from several types of shocks: China's sectoral productivity shocks, China's regional initial labor supply shocks, China's labor mobility cost shocks, China's intranational trade cost shocks, China's international trade cost shocks, and shocks from other regions. The latter category encompasses shocks to foreign economies' sectoral productivity, foreign economies' labor supply, and trade costs between foreign economies. The marginal effects of specific types of shocks are calculated by subtracting the value under the scenario where these shocks remain unchanged from the value under the baseline case (where all shocks are realized). Since the model is non-linear, the aggregated marginal effects of individual factors do not necessarily equal the marginal effects of all forces.

Table 10 illustrates the results of structural decomposition for different types of forces and some of their interactions. The marginal effects of a specific shock on the trade share are calculated as the difference between the trade share under the baseline scenario and its value when the specific shock remains unchanged. Similarly, in the same table, I also decompose the changes in two other macroeconomic variables: China's intranational trade share of GDP and China's real income per worker.

In Table 10, the row labeled "All forces" records the changes in trade share or other variables when all shocks change over time. In the main text, I conduct a structural accounting decomposition assuming balanced trade. Therefore, here I only report the international trade share of GDP, instead of the export or import share of GDP, which are equal.

21. The trade deficit to GDP ratio is set as an exogenous parameter, with adjustments made to the deficit of the rest of the world (ROW) to accommodate the global deficit.

From 2002 to 2007, the primary factor explaining the increase in China's international trade share was the decline in international trade costs, which led to an approximately 6.8 percentage point (p.p.) increase in China's trade share of GDP. The second significant factor was the increase in productivity in foreign economies, contributing to an increase of around 4.7 p.p. in China's international trade share of GDP. Conversely, the productivity growth of China exerted an equally important but inverse effect, reducing its trade share of GDP by about 8.4 p.p. The impact of other forces aligns with the model's expectations in direction but is relatively small in magnitude.

In terms of China's intranational trade share of GDP, the primary factors driving its increase include reduced intranational trade costs, which have led to a significant rise of approximately 14.3 p.p. in China's intranational trade share of GDP. Other factors have only a negligible impact, except for the productivity growth of China, which contributed a 3.8 p.p. increase in its intranational trade share.

Regarding the increase in China's real income per worker, the productivity growth of China plays a dominant role. Moreover, compared to the decrease in international trade costs, the reduction in intranational trade costs has nearly twice the impact on real income per worker.

From 2007 to 2015, China's productivity increase emerged as the main driving force, leading to a decline of approximately 12.5 p.p. in China's trade share of GDP. Although the reduction in China's import trade costs contributed to an increase, this effect was more than offset by the rising export trade costs, which drove the trade share down. The overall changes in international trade costs accounted for a decrease of about 3.6 p.p. in China's trade share of GDP. The effects of the remaining forces followed the anticipated direction but were relatively modest in magnitude.

Notably, China's intranational trade share of GDP increased by only 3.3 p.p. during this period. This increase is primarily attributed to decreased productivity in foreign regions.

Similar to the previous period, China's real income per worker continues to rise, largely driven by growth in productivity of China. Reduced labor mobility costs represent another force contributing to the growth inreal income per worker, exerting a greater effect compared to the previous period.

To summarize, during the period 2002 to 2007, the decline in international trade costs and the productivity growth of foreign regions were the two key forces behind the increase in China's international trade share of GDP. During the period 2007 to 2015, the productivity growth of China was the dominant force behind the decrease in China's trade share of GDP. Although the reduction in China's import trade costs contributed to a increase, it was more than offset by China's increasing export trade costs which driving the trade share down.

A full story about the contributions of some key forces (China's productivity shocks, international trade cost shocks, etc.) at a more disaggregated sector level or their interactions at a more aggregated level requires further counterfactual analysis.

6.2. Decomposition of Change in Trade Share of GDP at more disaggregated or aggregated Level

TABLE 11
STRUCTURAL ACCOUNTING DECOMPOSITION

Marginal effects	**2002 to 2007**			**2007 to 2015**		
	Trade Share of GDP change (p.p.)		Real GDP p.c. change (%)	Trade Share of GDP change (p.p.)		Real GDP p.c. change (%)
	Inter.	Intra.		Inter.	Intra.	
All Forces (Baseline)	**5.2**	**16.3**	**123.4**	**-9.4**	**3.3**	**164.5**
			Sectoral effects			
Productivity	**-8.4**	**3.8**	**102.1**	**-12.5**	**0.3**	**148.2**
Agriculture	-1.6	0.6	4.4	-1.6	-0.6	7.0
Light industry	-0.9	0.5	6.3	-0.6	-0.2	5.5
Heavy industry	-7.5	4.6	21.3	-7.7	3.1	32.6
Service	-5.9	-1.7	44.9	-13.7	-5.4	64.4
International Trade cost	**6.8**	**-1.6**	**2.7**	**-3.6**	**-1.2**	**-1.0**
Agriculture	-0.4	0.0	-0.1	-1.6	-0.1	-0.4
Light industry	0.2	-0.1	0.3	-0.3	0.0	-0.1
Heavy industry	5.2	-0.5	1.7	-0.7	0.9	-0.5
Service	0.3	-0.7	0.3	-4.5	-1.5	-1.2
Intranational Trade cost	**-1.2**	**14.3**	**4.0**	**0.0**	**-4.0**	**-1.5**
Agriculture	0.0	0.9	0.3	0.0	-0.6	-0.2
Light industry	0.0	1.3	0.3	0.1	-2.1	-0.7
Heavy industry	-0.9	5.4	1.5	0.4	-5.4	-1.8
Service	0.0	5.3	1.5	0.0	1.6	0.5
			Interact effects			
China's productivity and trade cost	**-1.3**	**17.4**	**118.2**	**-17.8**	**-0.5**	**146.9**
All region's productivity and trade cost	**3.7**	**17.2**	**120.9**	**-9.0**	**2.9**	**151.6**
All region's productivity	-2.4	3.3	105.5	-10.9	3.4	146.6
All region's trade cost	5.2	12.8	6.6	-2.5	-4.5	-1.9

Notes: This table analyzes the changes in China's trade shares of GDP and other variables by attributing them to various factors, such as changes in China's productivity, international trade costs, and intranational trade costs, at a more disaggregated level (e.g., sector level). Additionally, it examines the interaction of these factors at a more aggregated level. "China's productivity and trade cost" refers to the aggregate of productivity shocks in China with both China's international trade cost shocks and China's intranational trade cost shocks. The marginal effects of specific types of shocks are determined by comparing the values under the baseline scenario (where all shocks are realized) with those under a scenario where specific shocks remain unchanged. Since the model is non-linear, the aggregated marginal effects of individual factors do not necessarily equal the marginal effects of all forces.

In this section, I further decompose the contributions of key forces, such as China's productivity shocks, international trade costs, and intranational trade cost shocks, at a more disaggregated level. Additionally, I examine the interactions of these forces at a more aggregated level. The results are presented in Table 11.

From 2002 to 2007, as previously analyzed, the primary driver behind the increase in China's international trade share of GDP was the decline in international trade costs. Specifically, in the heavy industry sector, which constitutes a significant portion of China's total trade, the reduction in trade costs was the main force propelling the change in trade share, resulting in a 5.2 percentage point increase. Additionally, China's productivity growth also played a crucial role, albeit in the opposite direction. In the heavy industry sector, productivity growth led to a 7.5 percentage point decrease in trade share. Although services trade constitutes a smaller part of China's total trade, the productivity growth in this sector, facilitated by input-output linkages, was equally important, contributing to a 5.9 percentage point decrease in China's trade share of GDP.[22]

Regarding changes in China's intranational trade share at the sector level, the reduction of intranational trade costs in heavy industry and services is equally significant, resulting in approximately a 5.4 percentage point and 5.3 percentage point increase in intranational trade share, respectively. Regarding the increase in real income per worker, productivity growth in both the heavy industry and services sectors plays a crucial role, with the impact of services' productivity growth being greater than that of heavy industry.

From 2007 to 2015, China's productivity growth was the dominant force behind the decrease in China's trade share of GDP. At the sector level, the increase in China's productivity within the heavy industry sector led to a 7.7 percentage point decrease in the trade share of GDP. The growth of productivity in the services sector, facilitated by IO linkages and service sector productivity growth, resulted in an even larger decrease in the trade share by 13.7 percentage points. Additionally, international trade costs in the services sector were the primary force across sectors that drove the trade share decrease by 4.5 percentage points.

As mentioned earlier, the growth in China's intranational trade share of GDP from 2007 to 2015 is marginal. When examined at a more detailed level, the primary drivers for the increase in intranational trade share are the productivity growth in the heavy industry sector. For the growth of China's real income per worker, similar to the previous period, productivity growth in both the heavy industry and services sectors plays a crucial role.

In the final panel of Table 11, I further analyze the interaction effects of two or more forces. It demonstrates that, in both periods, while changes in China's productivity and trade costs individually play significant roles in influencing China's international trade share of GDP, their combined effects are insufficient to fully account for and explain shifts in trade shares.

To better elucidate changes in China's trade share of GDP, external factors also prove crucial. Specifically, changes in both China's productivity and trade costs, alongside those of foreign regions, effectively explain approximately 87% of the variation in China's trade

22. For details on input-output linkage coefficients of China's regions, refer to Table E.5 in Appendix E.

share.

To summarize, at a more disaggregated level, from 2002 to 2007, the decline in international trade costs in the heavy industry sector is key to explaining the increase in international trade share. China's productivity growth in the heavy industry sector is important but leads to a decrease in trade share. Through IO linkages, China's services sector productivity growth is equally important. From 2007 to 2015, the key forces driving China's trade share increase are the growth in productivity in the heavy industry sector and, through IO linkages, productivity growth in the services sector.

At a more aggregated level, during both periods, changes in productivity and trade costs for both China and foreign regions explain China's trade share changes better than changes in only China's productivity and trade costs.

7. Conclusion

In this paper, I present some key facts concerning China's increase in trade share of GDP in the early 2000s and its subsequent decline since 2006. To explain the change in China's trade share, I conduct a structural accounting decomposition through a static multi-sector, multi-country Ricardian model. The model features input-output linkages, international trade, inter-regional trade within China, and labor flow across regions within China. Specifically, the model is implemented with eight regions in mainland China, three foreign economy groups, and four sectors over the periods 2002-2007 and 2007-2015. The calibrated model replicates the change in China's trade share of GDP well.

Through structural accounting decompositions, I find that changes in productivity and trade costs for both China and foreign regions together explain approximately 87% of the change in China's trade share of GDP. During the period from 2002 to 2007, the decline in international trade costs, especially in the heavy industry sector, and the growth in productivity in foreign regions were the two dominant forces behind the increase in China's trade share of GDP. While China's regional productivity growth was also significant during this period, it was more than offset by the first two factors. During the period from 2007 to 2015, China's productivity growth became the dominant force behind the decrease in China's trade share of GDP. At the sector level, in both periods, changes in productivity in the heavy industry sector were key to explaining the change in China's trade share of GDP. Moreover, through input-output (IO) linkages, changes in productivity in the services sector were similarly important, even though services trade accounts for only a small part of China's total trade.

These shocks impact comparative advantage and specialization. On the one hand, in regions with higher productivity, a greater variety of goods are produced domestically, while fewer are imported. As a result, the proportion of total spending on domestic goods rises, leading to a reduction in the import share of GDP. This also results in a lower export-to-GDP ratio, despite an increase in export variety. This change is partly due to improvements in productivity, which lower export prices. Moreover, export trade must be balanced by import trade. Additionally, productivity increases in a particular sector can indirectly affect comparative advantage through input-output (IO) linkages. For example, a rise in productivity within the services sector can lower marginal costs in heavy industry, particularly when service products are key intermediate inputs for heavy industry. On the other hand, if the costs of international imports for China's regions decrease, then China will produce less and source more varieties from abroad. This will reduce the proportion of total spending on domestic goods and increase the import share of GDP. Conversely, a decrease in international export trade costs for China's regions will lead to higher exports of produced varieties. This will raise the proportion of exported goods in total production, thereby increasing the export share of GDP.

In the counterfactual experiments, the main text assumes that the ratio of trade deficit to regional GDP is zero, indicating a balanced trade scenario for each region. For robustness checks, I conduct analogous counterfactuals by treating the ratio of trade deficit to regional GDP as an exogenous variable. Additionally, I adjust the deficit of the region "ROW" (a aggregation of the rest of the World) to absorb the excess deficit. Allowing for an endogenous trade deficit within a dynamic trade model would offer more insights into how borrowing tendencies over time influence the change in the trade share of GDP. Additionally, ignoring the computational complexity, I can extend the groups of regions in China, foreign economies, and sectors to obtain more detailed information at both the regional and sectoral levels. I leave this exercise and others for future research.

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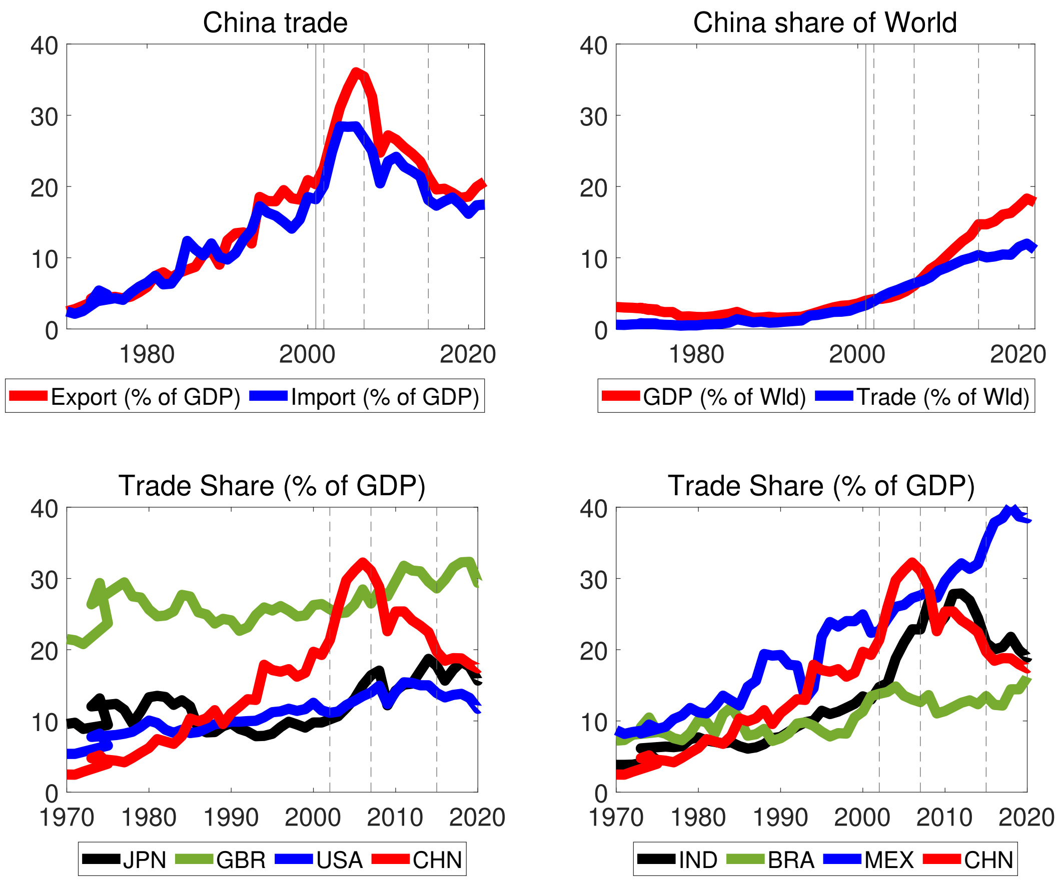
APPENDIX A: FIGURES



Note: The solid line denotes the year 2001, when China acceded to the WTO. The three dotted vertical lines indicate the years 2002, 2007, and 2015, which correspond to the periods for which counterfactual analysis was performed. The data utilized are sourced from the World Development Indicators (WDI) database.

FIGURE A.1
CHINA TRADE AND GDP DATA

TABLE A.1

Decomposition of China's Trade Share Change

Export (% of GDP)	2002 to 2007			2007 to 2015		
Change	Total	Within	Between	Total	Within	Between
Total	13.2	11.8	1.3	-16.6	-14.0	-2.6
Agriculture	-0.1	0.0	-0.1	-0.2	-0.1	-0.1
Light Industry	1.4	2.0	-0.6	-3.4	-3.1	-0.3
Heavy Industry	11.2	9.3	1.9	-11.1	-8.1	-3.0
Service	0.6	0.5	0.1	-1.9	-2.7	0.7
Import (% of GDP)	**2002 to 2007**			**2007 to 2015**		
Change	Total	Within	Between	Total	Within	Between
Total	6.3	4.7	1.6	-8.6	-6.5	-2.1
Agriculture	0.3	0.5	-0.2	-0.2	0.0	-0.2
Light Industry	-0.7	-0.5	-0.2	-0.3	-0.2	-0.1
Heavy Industry	5.8	3.9	1.9	-10.8	-8.4	-2.5
Service	0.9	0.8	0.0	2.8	2.1	0.7

Notes: This table is derived from the WIOD table. It implies sector-level bilateral trade flows between China and foreign economies. For detailed information, see Appendix E.

TABLE A.2

China trade share data

Average Trade (% of GDP)	**2002**	**2007**	**2015**		**2002**	**2007**	**2015**
Aggregate	21.6	31.1	18.7	-	-	-	-
Component classified by China regions							
NorthEast (NE)	1.2	2.0	0.7	SouthernCoastal (SC)	8.3	7.5	6.1
BeijingTianjin (BT)	1.7	2.8	1.6	Central (CE)	0.8	2.2	1.0
NorthernCoastal (NC)	1.6	2.8	1.8	NorthWest (NW)	0.4	1.6	0.5
EasternCoastal (EC)	7.1	10.8	6.1	SouthWest (SW)	0.5	1.3	0.8
Component classified by foreign regions							
USA	2.9	4.0	3.2	AUS	0.4	0.7	0.7
JPN	2.8	3.0	1.5	GBR	0.4	0.6	0.4
KOR	1.3	1.9	1.4	FRA	0.4	0.7	0.4
TWN	1.2	1.5	0.8	IND	0.2	0.5	0.5
DEU	1.0	1.7	0.8	ITA	0.3	0.5	0.3
NLD	0.2	0.3	0.1	CAN	0.3	0.6	0.4
RUS	0.3	0.6	0.4	ROW1	9.7	14.5	7.7
G6	5.3	7.9	5.5				
AS3	5.4	6.5	3.7	ROW2	10.9	16.7	9.5

Notes: The average trade share of GDP represents the mean value of import and export shares relative to GDP. For each region in China, the trade share of GDP is calculated by averaging the import and export trade values between that region and foreign countries, then dividing by China's total GDP. Similarly, for each foreign region, the trade share of GDP is computed by averaging the import and export trade values between that region and China, and dividing by China's total GDP.

Appendix B: Algebra

B.1. Deriving Labor Flow Function

The cumulative distribution function for the utility of people who migrates from location m to location n is

$$\begin{aligned} F^{n,m}(u) &= \Pr\left(V(\omega)^{n,m} \le u\right) \\ &= \Pr\left(\frac{z_n(\omega)\, W_n}{\nu^{n,m}} \le u\right) \\ &= \Pr\left(z_n(\omega) \le u \frac{\nu^{n,m}}{W_n}\right) \\ &= exp\left\{-(u)^{-\kappa}(\frac{W_n}{\nu^{n,m}})^{\kappa}\right\}, \end{aligned} \tag{B.1}$$

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

The cumulative distribution function for the utility of people from location m is

$$\begin{aligned} F^{m}(u) &= \Pr\left(max_{n'} V(\omega)^{n',m} \le u\right) \\ &= \prod_{n'=1}^{N_0} \Pr\left(z_{n'}(\omega) \le u \frac{\nu^{n',m}}{W_{n'}}\right) \\ &= \prod_{n'=1}^{N_0} exp\left\{-(u)^{-\kappa}\left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\} \\ &= exp\left\{-(u)^{-\kappa}\sum_{n'=1}^{N_0}\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\} \\ &= exp\left\{-(u)^{-\kappa}\Psi_m\right\}, \end{aligned} \tag{B.2}$$

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

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

$$
\begin{aligned}
m^{n,m} &= \Pr\left(V(\omega)^{n,m} \geq max_{n' \neq n} V(\omega)^{n',m}\right) \\
&= \int_0^{+\infty} \Pr\left(max_{n' \neq n} V(\omega)^{n',m} \leq u\right) dF(u)^{n,m} \\
&= \int_0^{+\infty} exp\left\{-(u)^{-\kappa} \sum_{n' \neq n} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\} dF(u)^{n,m} \\
&= \int_0^{+\infty} \frac{exp\left\{-(u)^{-\kappa} \sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\}}{exp\left\{-(u)^{-\kappa} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\}} dF(u)^{n,m} \\
&= \int_0^{+\infty} \frac{exp\left\{-(u)^{-\kappa} \sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\}}{exp\left\{-(u)^{-\kappa} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\}} exp\left\{-(u)^{-\kappa} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}\right\} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} d\left(-(u)^{-\kappa}\right) \\
&= \int_0^{+\infty} exp\left\{-(u)^{-\kappa} \sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}\right\} \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} d\left(-(u)^{-\kappa}\right) \\
&= \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} \int_0^{+\infty} exp\left\{-(u)^{-\kappa}\, \Psi_m\right\} d\left(-(u)^{-\kappa}\right) \\
&= \left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa} \int_{-\infty}^{0} exp\left\{t\, \Psi_m\right\} dt \\
&= \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\Psi_m} = \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'=1}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}}.
\end{aligned}
\tag{B.3}
$$

B.2. Trade Share of GDP under Frictionless Trade in a One-Sector Economy

Table B.1 lists equilibrium conditions of the one-sector model:

TABLE B.1
Equilibrium conditions of 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)	$W_n \equiv \frac{I_n}{P_nL_n}; \; w_nL_n + D_n = I_n$	$\forall n$
(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)	$X_n = (w_nL_n + D_n) + (1-\beta)\left(\sum_{i=1}^{N}\pi_{in}X_i\right) = \frac{w_nL_n}{\beta} + D_n$	$\forall n$
(MM2)	$\sum_{i=1}^{N}\pi_{in}X_i = \sum_{i=1}^{N}\pi_{ni}X_n - D_n$	$\forall n$
(MM2′)	$w_nL_n = \beta\left(\sum_{i=1}^{N}\pi_{in}X_i\right)$	$\forall n$

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

China's trade share of GDP

In the one-sector economy, under zero trade deficit, 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:

$$
\begin{aligned}
\text{TradeShare}_{CHN} &= \frac{\sum_{n\in\mathbb{N}_0} X_n\left(\sum_{i\in\mathbb{N}_1}\pi_{ni}\right)}{\sum_{n\in\mathbb{N}_0}\beta X_n} \\
&= \sum_{n\in\mathbb{N}_0}\frac{\beta X_n}{\sum_{n\in\mathbb{N}_0}\beta X_n}\frac{X_n\left(\sum_{i\in\mathbb{N}_1}\pi_{ni}\right)}{\beta X_n} \\
&= \frac{1}{\beta}\sum_{n\in\mathbb{N}_0}\psi_n\left(\sum_{i\in\mathbb{N}_1}\pi_{ni}\right),
\end{aligned}
\tag{B.4}
$$

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

Specifically, under zero trade deficit, I can prove that China's total imports equal to China's total exports.

$$China's\ imports = \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_1} X_{in}\right) \tag{B.5}$$

$$China's\ exports = \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_1} X_{ni}\right) \tag{B.6}$$

From zero trade deficit condition, I got

$$\sum_{i=1}^{N} X_{in} = \sum_{i=1}^{N} X_{ni}. \tag{B.7}$$

So

$$\sum_{i\in\mathbb{N}_1} X_{in} = \sum_{i=1}^{N} X_{ni} - \sum_{i\in\mathbb{N}_0} X_{in}, \tag{B.8}$$

$$\sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_1} X_{in}\right) = \sum_{n\in\mathbb{N}_0}\left(\sum_{i=1} X_{ni}\right) - \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_0} X_{in}\right), \tag{B.9}$$

and

$$\begin{aligned} China's\ imports \equiv \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_1} X_{in}\right) &= \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_0} X_{ni} + \sum_{i\in\mathbb{N}_1} X_{ni}\right) - \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_0} X_{in}\right) \\ &= \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_1} X_{ni}\right) \equiv China's\ exports. \end{aligned} \tag{B.10}$$

China's export implied value added in total value added

China's export implied value added in total value added equal to China's import implied value added in total value added, and it is proportional to China's trade share of GDP:

$$\frac{Value\ add\ contained\ in\ export}{Total\ value\ added} = \frac{\beta \sum_{n\in\mathbb{N}_0}\left(\sum_{i\in\mathbb{N}_1} X_i \pi_{in}\right)}{\sum_{n\in\mathbb{N}_0} \beta X_n} = \beta\ TradeShare_{CHN}. \tag{B.11}$$

Free trade under free trade, prices are equalized across countries:

$$P = P_n = A\left[\sum_{i=1}^{N} \lambda_i \left(\Upsilon {w_i}^{\beta} {P_i}^{(1-\beta)}\right)^{-\theta}\right]^{-1/\theta} = (A\Upsilon)^{1/\beta}\left[\sum_{i=1}^{N} \lambda_i \left(w_i\right)^{-\theta\beta}\right]^{-1/\theta\beta}. \tag{B.12}$$

From FF3, I have

$$\begin{aligned}
\pi_{ni} &= (A\Upsilon)^{-\theta}\,\lambda_i\left(\frac{w_i}{P_i}\right)^{-\beta\theta} \\
&= (A\Upsilon)^{-\theta}\,\lambda_i\,(w_i)^{-\beta\theta}\,(P_i)^{\beta\theta} \\
&= (A\Upsilon)^{-\theta}\,\lambda_i\,(w_i)^{-\beta\theta}\left((A\Upsilon)^{1/\beta}\left[\sum_{i=1}^{N}\lambda_i\,(w_i)^{-\theta\beta}\right]^{-1/\theta\beta}\right)^{\beta\theta} \\
&= \lambda_i\,(w_i)^{-\beta\theta}\left(\left[\sum_{i=1}^{N}\lambda_i\,(w_i)^{-\theta\beta}\right]^{-1}\right).
\end{aligned} \tag{B.13}$$

From MM1 and MM2, I obtain

$$\sum_{i=1}^{N}\pi_{in}w_iL_i = w_nL_n. \tag{B.14}$$

So I have

$$\sum_{i=1}^{N}\frac{w_iL_i}{\left[\sum_{m=1}^{N}\lambda_m\,(w_m)^{-\theta\beta}\right]}\lambda_n\,(w_n)^{-\beta\theta} = w_nL_n, \tag{B.15}$$

and

$$w_n = \left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}\left(\sum_{i=1}^{N}\frac{w_iL_i}{\left[\sum_{m=1}^{N}\lambda_m\,(w_m)^{-\theta\beta}\right]}\right)^{\frac{1}{1+\beta\theta}} = \left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}V, \tag{B.16}$$

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.12 and Equation B.16, I have

$$\begin{aligned}
\frac{w_n}{P_n} &= \left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}V(A\Upsilon)^{-1/\beta}\left[\sum_{i=1}^{N}\lambda_i\left(\left(\frac{\lambda_i}{L_i}\right)^{\frac{1}{1+\beta\theta}}V\right)^{-\theta\beta}\right]^{1/\theta\beta} \\
&= {L_n}^{-1}\left(\lambda_n{L_n}^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}(A\Upsilon)^{-1/\beta}\left[\sum_{i=1}^{N}\left(\lambda_i{L_i}^{\theta\beta}\right)^{\frac{1}{1+\beta\theta}}\right]^{1/\theta\beta} \\
&= (A\Upsilon)^{-1/\beta}\,{L_n}^{-1}\,(Z_n)^{\frac{1}{1+\beta\theta}}\left[\sum_{i=1}^{N}(Z_i)^{\frac{1}{1+\beta\theta}}\right]^{1/\theta\beta}.
\end{aligned} \tag{B.17}$$

From FF3, I have

$$\pi_{ni} = (A\Upsilon)^{-\theta} \lambda_i \left(\frac{w_i}{P_i}\right)^{-\beta\theta} = (Z_i)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{-1}. \tag{B.18}$$

Now, given China's Trade share of GDP I already derived:

$$\begin{aligned}
\text{TradeShare}_{CHN} &= \frac{\sum_{n\in\mathbb{N}_0} X_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right)}{\sum_{n\in\mathbb{N}_0} \beta X_n} \\
&= \sum_{n\in\mathbb{N}_0} \frac{\beta X_n}{\sum_{n\in\mathbb{N}_0} \beta X_n} \frac{X_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right)}{\beta X_n} \\
&= \frac{1}{\beta} \sum_{n\in\mathbb{N}_0} \psi_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right),
\end{aligned} \tag{B.19}$$

, where $n \in \mathbb{N}_0$ are regions within China, $n \in \mathbb{N}_1$ are foreign regions and ψ_n is defied as the region n's GDP share of China's GDP.

From MM2, I have $\sum_{i=1}^{N} \pi_{in} w_i L_i = w_n L_n$; from Equation B.18, I 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 I get

$$\psi_n = \frac{(Z_n)^{\frac{1}{1+\beta\theta}}}{\sum_{n\in\mathbb{N}_0} (Z_n)^{\frac{1}{1+\beta\theta}}}. \tag{B.20}$$

Then I have

$$\text{TradeShare}_{CHN} = \frac{1}{\beta} \sum_{n\in\mathbb{N}_0} \psi_n \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta} \sum_{n\in\mathbb{N}_0} \frac{(Z_n)^{\frac{1}{1+\beta\theta}}}{\sum_{n\in\mathbb{N}_0} (Z_n)^{\frac{1}{1+\beta\theta}}} \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right) = \frac{1}{\beta} \left(\sum_{i\in\mathbb{N}_1} \pi_{ni}\right). \tag{B.21}$$

From Equation B.18 and HH2, I get

$$\frac{w_n}{P_n} = (A\Upsilon)^{-\frac{1}{\beta}} {L_n}^{-1} (Z_n)^{\frac{1}{1+\beta\theta}} \left[\sum_{i=1}^{N} (Z_i)^{\frac{1}{1+\beta\theta}}\right]^{\frac{1}{\theta\beta}} = (A\Upsilon)^{-\frac{1}{\beta}} {L_n}^{-1} (Z_n)^{\frac{1}{1+\beta\theta}} \Lambda, \tag{B.22}$$

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

$$L_n = \sum_{m}^{N_0} \frac{\left(\frac{W_n}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N_0} \left(\frac{W_{n'}}{\nu^{n',m}}\right)^{\kappa}} \bar{L}_m = \sum_{m}^{N_0} \frac{\left(\frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{1}{1+\beta\theta}}}{\nu^{n,m}}\right)^{\kappa}}{\sum_{n'}^{N_0} \left(\frac{\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{1}{1+\beta\theta}}}{\nu^{n',m}}\right)^{\kappa}} \bar{L}_m. \tag{B.23}$$

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

$$\frac{L_n}{\sum_m^{N_0} \bar{L}_m} = \frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'}^{N_0} \left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}} \tag{B.24}$$

So, I get

$$\frac{\lambda_n}{\lambda_m} = \left(\frac{L_n}{L_m}\right)^{\frac{1+\beta\theta+\kappa}{\kappa}}, \tag{B.25}$$

and

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

So, I have

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

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

$$
\begin{aligned}
\lim_{\nu^{n,m,n\neq m}\to+\infty} L_n &= \lim_{\nu^{n,m,n\neq m}\to+\infty} \sum_{m}^{N_0} \frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'}^{N_0}\left(\frac{\nu^{n,m}}{\nu^{n',m}}\right)^{\kappa}\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}}\bar{L}_m \\
&= \lim_{\nu^{n,m,n\neq m}\to+\infty}\left[\frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'}^{N_0}\left(\frac{1}{\nu^{n',n}}\right)^{\kappa}\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}}\bar{L}_n + \sum_{m\neq n}^{N_0}\frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'}^{N_0}\left(\frac{\nu^{n,m}}{\nu^{n',m}}\right)^{\kappa}\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}}\bar{L}_m\right] \\
&= \bar{L}_n + \lim_{\nu^{n,m,n\neq m}\to+\infty}\sum_{m\neq n}^{N_0}\frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'=m}^{N_0}\left(\frac{\nu^{n,m}}{\nu^{n',m}}\right)^{\kappa}\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}} + \sum_{n'\neq m}^{N_0}\left(\frac{\nu^{n,m}}{\nu^{n',m}}\right)^{\kappa}\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}}\bar{L}_m \\
&= \bar{L}_n + \lim_{\nu^{n,m,n\neq m}\to+\infty}\sum_{m\neq n}^{N_0}\frac{\left(\frac{\lambda_n}{L_n}\right)^{\frac{\kappa}{1+\beta\theta}}}{\sum_{n'=m}^{N_0}\left(\nu^{n,m}\right)^{\kappa}\left(\frac{\lambda_m}{L_m}\right)^{\frac{\kappa}{1+\beta\theta}} + \sum_{n'\neq m}^{N_0}\left(\frac{\lambda_{n'}}{L_{n'}}\right)^{\frac{\kappa}{1+\beta\theta}}}\bar{L}_m \\
&= \bar{L}_n
\end{aligned}
\tag{B.28}
$$

So, I have

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

Appendix C: Algorithm

Table C.1 lists the entire set of equilibrium conditions in our model, and algorithm 1 describes the procedure 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)	$P_n^j = A^j (\sum_{i=1}^{N} \lambda_i^j \left(\kappa_{ni}^j c_i^j\right)^{-\theta})^{-\frac{1}{\theta}}$; $A^j = \Gamma\left(\frac{1+\theta-\sigma^j}{\theta}\right)^{\frac{1}{(1-\sigma^j)}}$	$\forall(n,j)$
(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 $P_{n\,0}^{k\,0}$. From F1 F2 generate $P_{n\,0}^{k\,1}$, then iterate until $P_{n\,0}^{k\,1}$ convergence.
4: Given w_{n0} $P_{n\,0}^{k\,1}$, From F3, calculate π_{ni0}^j.
5: Guess L_{n0}^0. From $P_{n\,0}^{k\,1}$, H1, H2, H3, H4, generate L_{n0}^1, then iterate until L_{n0}^1 convergence.
6: From w_{n0}, L_{n0}^1, $P_{n\,0}^{k\,1}$, H2, M1, generate X_{n0}^j, 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 M2 or M2′ holds.

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

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

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

such that world GDP always equal to a constant. $v \in (0,1)$ controls convergence speed. Here, I set $v = 0.5$.

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

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

Appendix D: Calibration

D.1. Gravity Equation Regression

This section list the results of gravity equation regression which is used in the calibration part.

TABLE D.1

Gravity Equation Calibration Results

Sector	Agriculture			Light Industry			Heavy industry			Services		
Year	2002	2007	2015	2002	2007	2015	2002	2007	2015	2002	2007	2015
Variables	lnx_ninn1	lnx_ninn1	lnx_ninn1	lnx_ninn2	lnx_ninn2	lnx_ninn2	lnx_ninn3	lnx_ninn3	lnx_ninn3	lnx_ninn4	lnx_ninn4	lnx_ninn4
logdist	-2.18***	-1.81***	-1.32***	-1.83***	-1.64***	-0.92***	-1.79***	-1.44***	-1.10***	-2.09***	-1.84***	-1.02***
	(-6.92)	(-6.16)	(-4.80)	(-7.81)	(-8.47)	(-3.80)	(-8.11)	(-8.97)	(-5.29)	(-7.86)	(-7.64)	(-3.61)
IMd1	0.18	-1.26**	0.35	1.10***	0.80**	1.23***	1.49***	1.33***	1.10***	2.10***	2.52***	2.35***
	(0.35)	(-2.58)	(0.76)	(2.81)	(2.49)	(3.04)	(4.07)	(4.94)	(3.18)	(4.73)	(6.30)	(5.00)
IMd2	0.65	1.16**	3.02***	2.13***	1.68***	2.06***	2.22***	1.55***	1.56***	3.03***	2.60***	2.31***
	(1.16)	(2.23)	(6.23)	(5.14)	(4.94)	(4.81)	(5.72)	(5.46)	(4.27)	(6.45)	(6.14)	(4.64)
IMd3	-1.18**	0.09	0.68	0.44	-0.14	-0.59	1.29***	0.58**	-0.47	2.35***	2.36***	1.73***
	(-2.10)	(0.17)	(1.39)	(1.04)	(-0.39)	(-1.36)	(3.28)	(2.00)	(-1.27)	(4.95)	(5.49)	(3.44)
IMd4	-0.43	0.91*	1.49***	-0.22	0.22	0.86**	1.08***	0.97***	1.22***	1.95***	1.66***	2.02***
	(-0.78)	(1.78)	(3.12)	(-0.55)	(0.65)	(2.04)	(2.82)	(3.47)	(3.39)	(4.22)	(3.97)	(4.14)
IMd5	-0.58	0.62	2.20***	1.38***	1.22***	0.99**	2.45***	2.04***	1.26***	3.13***	2.73***	2.57***
	(-1.11)	(1.28)	(4.80)	(3.54)	(3.81)	(2.45)	(6.70)	(7.60)	(3.65)	(7.07)	(6.83)	(5.49)
IMd6	-1.36**	-0.60	0.11	-0.29	0.27	-0.13	0.96**	1.17***	0.33	1.50***	2.76***	1.75***
	(-2.47)	(-1.17)	(0.24)	(-0.71)	(0.80)	(-0.31)	(2.49)	(4.16)	(0.91)	(3.22)	(6.58)	(3.55)
IMd7	0.23	0.17	0.26	1.63***	1.83***	1.25***	2.13***	1.79***	1.11***	2.85***	3.57***	2.29***
	(0.43)	(0.35)	(0.56)	(4.12)	(5.59)	(3.03)	(5.72)	(6.57)	(3.17)	(6.34)	(8.79)	(4.80)
IMd8	-1.68***	-0.65	0.22	0.16	1.00***	0.95**	1.25***	1.57***	1.10***	3.33***	3.32***	2.10***
	(-3.22)	(-1.34)	(0.48)	(0.41)	(3.12)	(2.35)	(3.41)	(5.89)	(3.19)	(7.54)	(8.32)	(4.50)
IMd9	1.28*	0.79	1.03*	1.71***	1.80***	0.97*	2.32***	1.85***	1.39***	2.27***	1.83***	0.42
	(1.85)	(1.24)	(1.70)	(3.33)	(4.25)	(1.82)	(4.81)	(5.24)	(3.05)	(3.89)	(3.48)	(0.68)
IMd11	0.91	0.50	-0.16	1.65***	1.39***	0.47	2.17***	1.63***	1.29***	4.17***	3.41***	0.94*
	(1.46)	(0.86)	(-0.29)	(3.55)	(3.63)	(0.97)	(4.98)	(5.12)	(3.14)	(7.93)	(7.17)	(1.69)
EXo1	11.06***	8.89***	4.95**	7.58***	7.19***	2.09	7.49***	5.68***	2.89*	7.09***	5.36***	0.65
	(4.43)	(3.82)	(2.27)	(4.07)	(4.69)	(1.09)	(4.29)	(4.45)	(1.76)	(3.36)	(2.81)	(0.29)
EXo2	8.31***	5.65**	1.54	6.19***	5.88***	0.79	6.34***	4.72***	2.83*	6.74***	6.43***	1.07
	(3.50)	(2.55)	(0.74)	(3.49)	(4.03)	(0.43)	(3.82)	(3.88)	(1.80)	(3.35)	(3.54)	(0.50)
EXo3	10.49***	8.82***	4.04*	8.42***	7.58***	2.21	6.76***	5.30***	3.05*	5.76***	5.73***	0.70
	(4.45)	(4.01)	(1.96)	(4.79)	(5.23)	(1.22)	(4.10)	(4.40)	(1.96)	(2.89)	(3.18)	(0.33)
EXo4	8.79***	5.17**	3.26	9.21***	7.42***	2.95	7.97***	6.11***	4.42***	7.80***	5.63***	2.16
	(3.66)	(2.31)	(1.55)	(5.14)	(5.03)	(1.59)	(4.74)	(4.97)	(2.79)	(3.84)	(3.06)	(1.00)
EXo5	11.63***	6.63***	4.46**	9.96***	8.88***	3.21	8.88***	6.70***	4.04**	7.79***	5.85***	1.30
	(4.64)	(2.84)	(2.03)	(5.33)	(5.77)	(1.66)	(5.06)	(5.22)	(2.44)	(3.68)	(3.06)	(0.58)
EXo6	11.22***	7.95***	4.25**	8.39***	6.86***	2.63	7.24***	5.35***	3.77**	6.40***	5.54***	0.90
	(4.69)	(3.57)	(2.04)	(4.70)	(4.67)	(1.42)	(4.33)	(4.38)	(2.39)	(3.17)	(3.03)	(0.42)
EXo7	10.98***	9.37***	4.52**	7.36***	7.06***	1.22	6.55***	5.25***	2.94*	6.49***	6.38***	0.84
	(4.47)	(4.09)	(2.11)	(4.02)	(4.68)	(0.64)	(3.81)	(4.18)	(1.82)	(3.12)	(3.40)	(0.38)
EXo8	11.14***	8.60***	5.14**	8.78***	7.11***	2.14	7.23***	4.95***	3.31**	6.55***	5.85***	0.58
	(4.42)	(3.66)	(2.34)	(4.68)	(4.60)	(1.10)	(4.10)	(3.84)	(2.00)	(3.08)	(3.04)	(0.26)
EXo9	14.75***	12.37***	7.07***	11.66***	10.22***	3.38	11.48***	9.03***	5.65***	11.66***	9.86***	3.48
	(4.89)	(4.40)	(2.68)	(5.19)	(5.52)	(1.45)	(5.45)	(5.86)	(2.85)	(4.58)	(4.28)	(1.29)
EXo10	8.85***	5.56**	1.24	9.45***	7.45***	0.99	9.41***	7.35***	4.26**	7.74***	6.31***	1.13
	(3.44)	(2.32)	(0.55)	(4.92)	(4.71)	(0.50)	(5.23)	(5.58)	(2.51)	(3.56)	(3.21)	(0.49)
EXo11	15.88***	13.13***	7.42***	12.56***	10.87***	4.04*	11.78***	9.49***	6.03***	11.77***	10.17***	3.59
	(5.46)	(4.85)	(2.92)	(5.80)	(6.09)	(1.80)	(5.80)	(6.39)	(3.15)	(4.79)	(4.58)	(1.38)
Observations	110	110	110	110	110	110	110	110	110	110	110	110
R-squared	0.974	0.976	0.974	0.975	0.979	0.968	0.974	0.982	0.971	0.982	0.981	0.968

t-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The 10th region is AS3 (an aggregation of Japan, Korea, and Taiwan), I use this region as reference location. The importer fixed effects for AS3 is set to $IM10 \equiv 0$.

D.2. Calibrated Shocks

Figure D.1 displays the productivity changes relevant to the base year for both the period 2002-2007 and period 2007-2015.

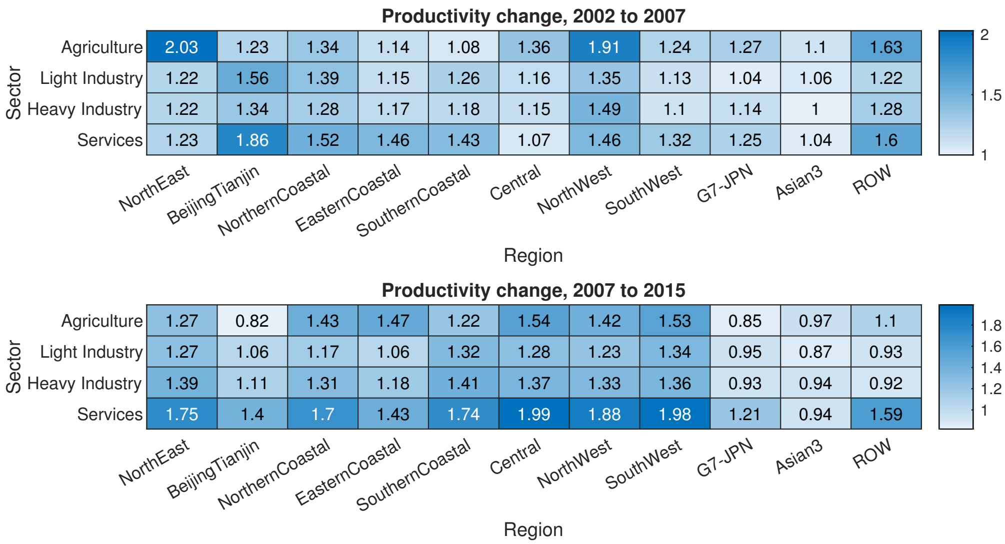


Figure D.1
Calibration Results: Productivity $({\lambda_n^j}^{1/\theta})$ Change

Figure D.2 displays the changes in labor mobility costs relevant to the base year for both the period 2002-2007 and period 2007-2015.

Figure D.2
Calibration Results: Labor mobility cost change

Figure D.3 and Figure D.4 displays the average trade cost changes relevant to the base year for both the period 2002-2007 and period 2007-2015.

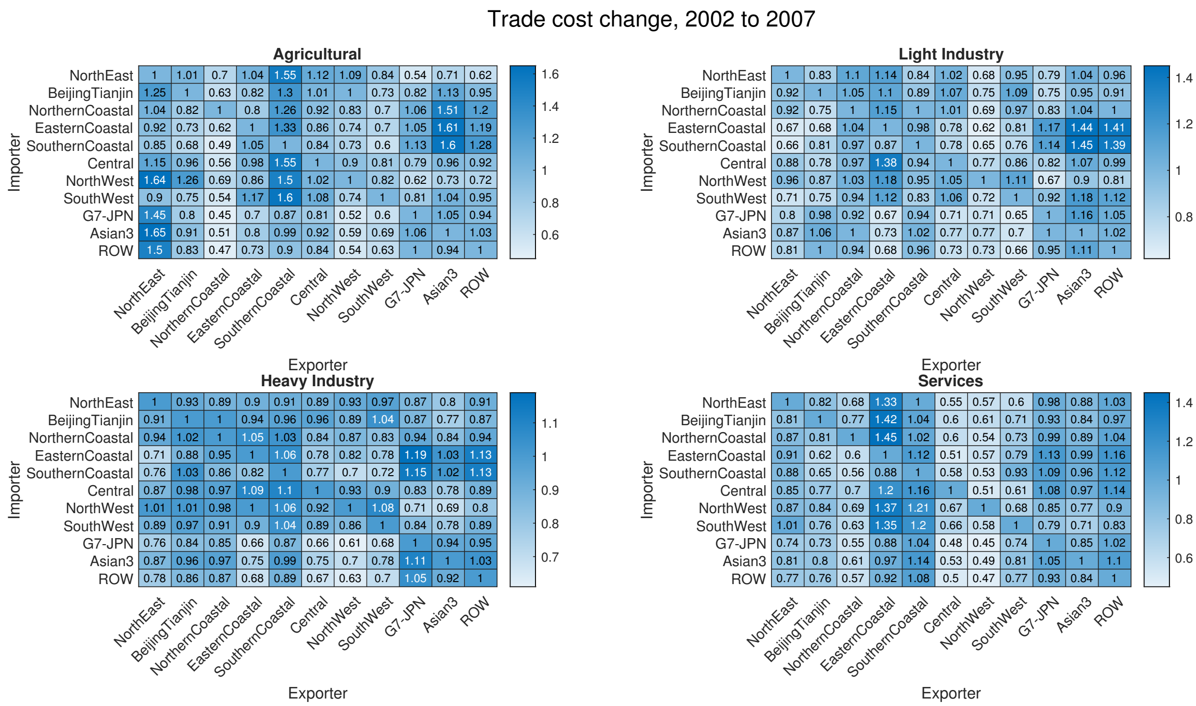


Figure D.3
Calibration Results: Trade cost change - 2002 to 2007

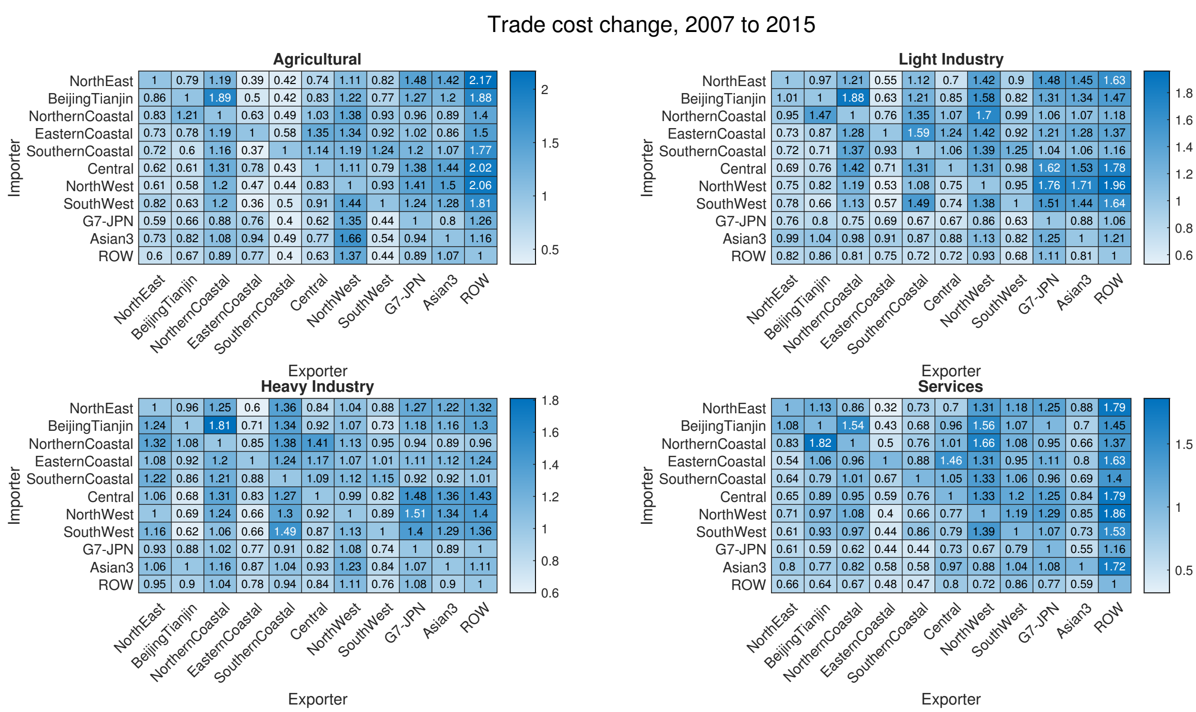


Figure D.4
Calibration Results: Trade Cost Change - 2007 to 2015

Appendix E: Data

The data utilized in this paper include: the 5th National Census Data from 2000; the 6th National Census Data from 2005, which is the most recent available labor flow data near the years 2002 and 2007; and the 7th National Census Data from 2015. Additional sources are the Penn World Table (PWT) 10.0 for the years 2002, 2007, and 2015 (Feenstra, Inklaar and Timmer, 2015); the World Input-Output Database (WIOD) for 2002 and 2007, along with the WIOD Socio-Economic Accounts Database (Timmer et al., 2015); the OECD Inter-Country Input-Output (ICIO) Tables for 2015 (OECD, 2021); the China Cross Regional Input-Output Table for 2002, 2007, and 2015 (Zhang and Qi, 2012; Zheng et al., 2020); and the Centre d'Études Prospectives et d'Informations Internationales (CEPII) (Head and Mayer, 2014).

E.1. Data Concordance

This section demonstrates how I aggregate data from various sources into a version encompassing 4 sectors and 11 regions.

Sectors Classification

TABLE E.1
Sector Classification

Unified IO table		2002 China IO table		2007 China IO table	
4 sector	Description	8 sector	Description	17 sector	Description
1	Agriculture	1	Farming, forestry, animal husbandry, fishery, industry	1	Farming, forestry, animal husbandry, fishery, industry
3	Heavy industry	2	Mining and Quarrying	2	Mining and Quarrying
2	Light industry	3	Light manufacture	3	Food production and tobacco processing
				4	Textile and garment industry
				5	Wood processing and furniture manufacturing
				6	Paper printing and stationery and sporting goods manufacturing industry
3	Heavy industry	4	Heavy manufacture	7	The petrochemical industry
				8	Non-metallic mineral products
				9	Metal smelting and products
				10	Mechanical industry
				11	Transportation equipment manufacturing industry
				12	Electrical and electronic equipment manufacturing industry
				13	Other manufacturing
		5	Electricity and steam, gas, hot water, tap water production and supply industry	14	Electricity and steam, gas, hot water, tap water production and supply industry
4	Services	6	The construction industry	15	The construction industry
		7	Goods transportation and warehousing	16	Goods transportation and warehousing
		8	Other services	17	Other services

TABLE E.2
SECTOR CLASSIFICATION ISIC_REV4

ISIC_rev4	Sector description	ISIC_rev4 Code	Sector description
Agriculture		F	Construction
A01	Crop and animal production, hunting and related service activities	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
A02	Forestry and logging	G46	Wholesale trade, except of motor vehicles and motorcycles
A03	Fishing and aquaculture	G47	Retail trade, except of motor vehicles and motorcycles
Light industry		H49	Land transport and transport via pipelines
C10-C12	Manufacture of food products, beverages and tobacco products	H50	Water transport
C13-C15	Manufacture of textiles, wearing apparel and leather products	H51	Air transport
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	H52	Warehousing and support activities for transportation
C17	Manufacture of paper and paper products	H53	Postal and courier activities
C18	Printing and reproduction of recorded media	I	Accommodation and food service activities
Heavy industry		J58	Publishing activities
B	Mining and quarrying	J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
C19	Manufacture of coke and refined petroleum products	J61	Telecommunications
C20	Manufacture of chemicals and chemical products	J62_J63	Computer programming, consultancy and related activities; information service activities
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	K64	Financial service activities, except insurance and pension funding
C22	Manufacture of rubber and plastic products	K65	Insurance, reinsurance and pension funding, except compulsory social security
C23	Manufacture of other non-metallic mineral products	K66	Activities auxiliary to financial services and insurance activities
C24	Manufacture of basic metals	L68	Real estate activities
C25	Manufacture of fabricated metal products, except machinery and equipment	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
C26	Manufacture of computer, electronic and optical products	M71	Architectural and engineering activities; technical testing and analysis
C27	Manufacture of electrical equipment	M72	Scientific research and development
C28	Manufacture of machinery and equipment n.e.c.	M73	Advertising and market research
C29	Manufacture of motor vehicles, trailers and semi-trailers	M74_M75	Other professional, scientific and technical activities; veterinary activities
C30	Manufacture of other transport equipment	N	Administrative and support service activities
C31_C32	Manufacture of furniture; other manufacturing	O84	Public administration and defence; compulsory social security
C33	Repair and installation of machinery and equipment	P85	Education
D35	Electricity, gas, steam and air conditioning supply	Q	Human health and social work activities
E36	Water collection, treatment and supply	R_S	Other service activities
E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
Services		U	Activities of extraterritorial organizations and bodies

Table E.1 and Table E.2 present sector classifications for data from various sources. The classifications for China's Cross-Region IO tables in 2002 and 2007 follow China's Industry Classification (see Table E.1). In contrast, the sector classifications for the WIOD tables, the OECD IRIO Table, and China's Cross-Region IO table for 2015 are based on the International Standard Industrial Classification of All Economic Activities, Revision 4. (see

Table E.2).

Mainland China's 8 Regions

TABLE E.3
MAINLAND CHINA'S 8 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

Table E.3 shows the classification of mainland China's 8 regions.

E.2. Sectoral price data for the region AS3

The region AS3 encompasses Korea, Japan, and China Taiwan. Sectoral intermediate input price data P_n^j and sectoral intermediate input values X_n^j for these three economies in the years 2002, 2007, and 2014 are sourced from the WIOD Socio-Economic Accounts Database. The sectoral price for region AS3 is computed using the following formula:

$$P_{AS3,t}^j = \frac{\sum_{n=KOR,JPN,TWN} X_{n,t}^j}{\sum_{n=KOR,JPN,TWN} \frac{X_{n,t}^j}{P_{n,t}^j}}. \tag{E.1}$$

Given that the WIOD Socio-Economic Accounts Database extends only through 2014, the sectoral intermediate input price for 2015 is linearly interpolated using prices from 2011 and 2014:

$$P_{AS3,2015}^j = P_{AS3,2014}^j + (2015 - 2011)\,\frac{P_{AS3,2014}^j - P_{AS3,2011}^j}{2014 - 2011}. \tag{E.2}$$

E.3. Labor flow matrix and Country Level Total Employment

The data on inter-provincial labor migration in China are derived from the China Population Census (2000) and the China Population 1% Sampling Survey (2005, 2015). These national census datasets exclude individuals in active military service and report both hukou registration province and residing province for the survey years. The official reports are available in two formats: one containing confidential micro-level data and the other providing provincial-level aggregates. The provincial-level reports specify the number of individuals residing in province A but registered in province B. For this study, due to data availability constraints, I utilize the provincial-level data to construct China's labor flow matrix at the regional level.

I compute the population flow shares for the years 2000, 2005, and 2015. In the absence of population flow data for 2002 and 2007, I approximate these years using the data from 2000 and 2005. The aggregate labor force data are obtained from PWT 10.01, which reports the number of persons engaged (in millions) by year and country.

E.4. Add the AS3 (Korea, Japan, and Taiwan), G6 (G7 country group without Japan), and aggregated rest of the world (ROW) to the China regional level IO Table

This section details the integration of the AS3 (Korea, Japan, and Taiwan), G6 (G7 countries excluding Japan), and the aggregated rest of the world (ROW) into the China regional-level Input-Output (IO) Table. The resulting unified IO Table encompasses sector-level bilateral trade flows among 11 regions (8 Chinese regions plus AS3, G6, and ROW). This table was constructed using the OECD ICIO Table and the China MRIO Table, with all values scaled and recorded at current prices, expressed in millions of dollars.

To assess the accuracy of the merged unified IO Table, I calculated and compared the key variable—trade share of GDP—from various sources, as illustrated in Table E.4. The comparison reveals that the unified IO Table aligns well with both the original China IO Table and World IO Table. Specifically, the trade share of GDP and its sectoral components for each year and trade type (imports, exports, and inter-regional trade within China) from different sources are nearly identical. Consequently, the unified IO Table demonstrates a high level of accuracy and reliability for related research.

The left side of Figure E.1 displays a schematic representation of three tables: the China cross-region IO Table, the World IO Table, and the combined Unified IO Table. The right side shows these tables with added colors and annotations to illustrate how the China cross-region IO Table and the World IO Table are merged to form the Unified IO Table.

In all these tables, area Z represents sector-level bilateral trade flows of intermediate goods, while area F represents trade flows of final goods. Each row indicates a source location-sector, and each column denotes a destination location-sector or destination location. The last column (area XX) reflects the gross output for each location-sector. The bottom two rows (areas VA and XX) illustrate the value-added and total input for each location-sector.

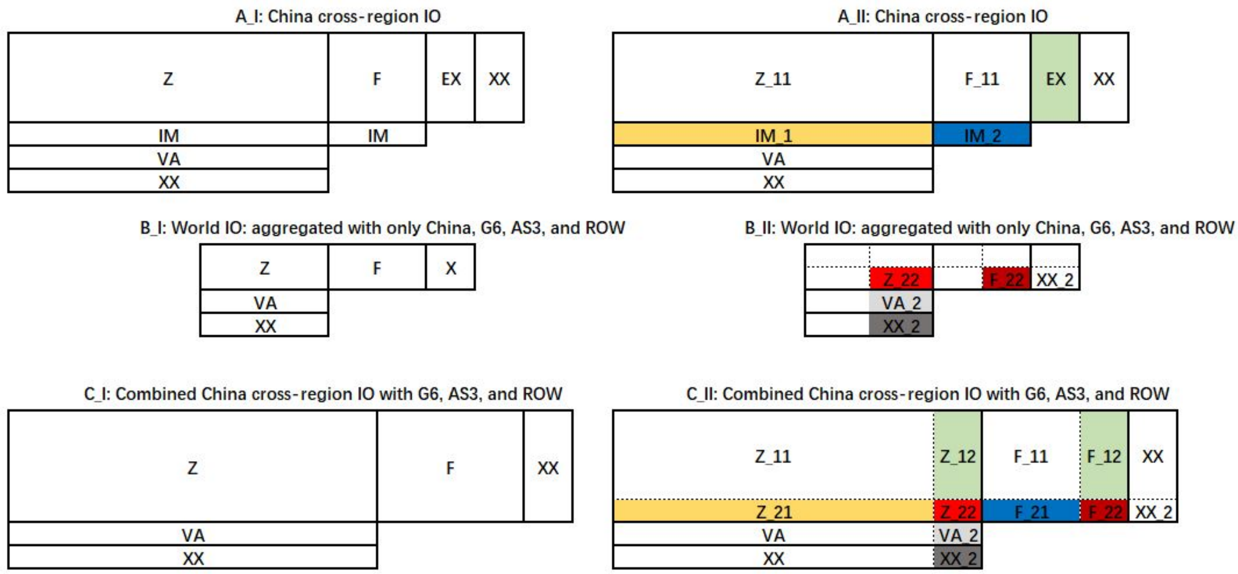


Figure E.1

An example for China IO Table, World IO Table, and combined unified IO table

Specifically, Figure E.1 Table A presents the collapsed China cross-region IO Table, encompassing 8 regions and 4 sectors (agriculture, light industry, heavy industry, services), aggregated across sectors and regions from China's regional IO table. Figure E.1 Table B depicts the World IO Table, including 4 regions (China, AS3, G6, and ROW) and 4 sectors, aggregated from the OECD ICIO Table or WIOD IO table. Figure E.1 Table C provides a schematic IO Table with 11 regions (8 Chinese regions plus AS3, G6, and ROW) and 4 sectors, created by merging data from Figure E.1 Part A and Part B.

Steps of merging World IO Table to the China cross-region IO Table

Step 1 Scaling of Z_{11}, F_{11}, IM, EX in the China IO table to match the sectoral aggregated values in the World IO table.

Since Table AII is recorded at current prices in ten thousand yuan, I scale the values of Z_{11}, F_{11}, IM, EX, and VA in Table AII so that their aggregated totals match the corresponding sectoral values in the World IO table. Consequently, the scaled Table AII is now recorded at current prices in millions of dollars.

Step 2 Area Z_{11} and area F_{11} in the unified IO table.

The values for area Z_{11} and area F_{11} in Table CII are derived directly from the scaled values of area Z_{11} and F_{11} in Table AII.

Step 3 Area Z_{12}, F_{12}, Z_{21}, and F_{21} in the unified IO table.

The aggregation across columns for areas Z_{12} and F_{12} in Table CII corresponds to the scaled value of area EX in Table AII. Specifically, areas Z_{12} and F_{12} in the unified IO table collectively match the scaled EX in Table AII. Allocation ratios for each row in Z_{12} and F_{12} of Table CII are calculated using data from the World IO table, which provides insights into China's sectoral export distribution. These ratios are applied uniformly across China's eight regions to estimate sectoral export allocations for each region.

Similarly, the aggregation across rows for areas Z_{21} and F_{21} in Table CII aligns with the scaled values of areas IM_1 and IM_2 in Table AII. Thus, areas Z_{21} and F_{21} in the unified IO table match the scaled IM_1 and IM_2 in Table AII. Allocation ratios for each column in Table CII are derived from the World IO table, reflecting China's sectoral import distribution. These ratios are used to estimate sectoral import allocations for each of China's eight regions. Consequently, the sectoral imports and exports of China's regions in Table CII are consistent with the aggregated values in the World IO table.

Step 4 Area Z_{22} and F_{22} in the unified IO table.

Areas Z_{22} and F_{22} in the unified IO table are directly obtained from their counterparts in the World IO table, representing sectoral trade flows among G6, AS3, and ROW.

Step 5 Area VA and VA_2 in the unified IO table.

Areas VA and VA_2 in the unified IO table are calculated as the difference between sectoral total outputs and sectoral total intermediate inputs. For the unified IO Table CII with 11 regions and 4 sectors, zero values are replaced with $1E-9$.

Data Accuracy Check

To assess the accuracy of the data in the unified IO table, I compute and compare the key variable, the trade share of GDP, from multiple sources. As shown in Table E.4, the table presents the values of the trade share of GDP and its sectoral components for each year and trade type (imports, exports, and inter-regional trade within China), derived from various sources. The observations in Table E.4 indicate that the trade share indices and their components from different sources are nearly identical, with the exception of the inner trade share of GDP. The value from the unified IO table exhibits slight deviations compared to the China IO table. Nevertheless, the inner trade share from the unified IO table maintains the same trend as its counterpart from the China IO table. In conclusion, the unified IO table we have constructed demonstrates a high level of accuracy and reliability for relevant research.

TABLE E.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	28.02	26.95
	2007	25.97	25.97	26.76	36.66	36.66	35.43	48.64	51.26
	2015	17.41	17.39	18.11	20.01	20.01	21.35	48.29	50.53
agriculture Component	2002	0.48	0.48	-	0.37	0.37	-	1.45	1.37
	2007	0.81	0.81	-	0.31	0.31	-	2.54	2.32
	2015	0.61	0.61	-	0.14	0.14	-	2.41	2.23
Light Industry Component	2002	2.03	2.03	-	5.21	5.21	-	4.75	4.51
	2007	1.37	1.37	-	6.61	6.61	-	6.31	6.95
	2015	1.07	1.07	-	3.17	3.17	-	5.81	6.11
Heavy Industry Component	2002	15.16	15.16	-	12.98	12.98	-	17.07	16.33
	2007	20.92	20.92	-	24.22	24.22	-	28.00	31.29
	2015	10.08	10.08	-	13.13	13.13	-	23.95	24.41
Services Component	2002	2.01	2.01	-	4.91	4.91	-	4.75	4.74
	2007	2.88	2.88	-	5.51	5.51	-	11.78	10.69
	2015	5.65	5.65	-	3.59	3.59	-	16.11	17.79

Notes: This table lists the values of the 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 tables are from three different years: 2002 and 2007 from the WIOD dataset, and 2015 from the OECD dataset.

TABLE E.5
INPUT-OUTPUT LINKAGE COEFFICIENTS OF CHINA'S REGIONS

Input-Output linkages	**Destination sector**							
	Agriculture	Light	Heavy	Services	Agriculture	Light	Heavy	Services
Source sector	Average cross China regions				China			
Agriculture	0.17	0.23	0.01	0.02	0.16	0.21	0.01	0.02
Light	0.10	0.28	0.02	0.06	0.09	0.32	0.03	0.06
Heavy	0.14	0.10	0.58	0.24	0.12	0.11	0.59	0.24
Services	0.09	0.12	0.13	0.21	0.08	0.11	0.13	0.22
Source sector	NorthEast				BeijingTianjin			
Agriculture	0.16	0.29	0.01	0.02	0.22	0.14	0.00	0.01
Light	0.12	0.22	0.01	0.06	0.11	0.31	0.01	0.05
Heavy	0.13	0.09	0.55	0.26	0.23	0.13	0.62	0.22
Services	0.08	0.10	0.13	0.19	0.17	0.14	0.15	0.26
	NorthernCoastal				EasternCoastal			
Agriculture	0.16	0.26	0.01	0.02	0.12	0.13	0.01	0.02
Light	0.09	0.36	0.04	0.07	0.11	0.36	0.03	0.05
Heavy	0.14	0.11	0.64	0.25	0.13	0.14	0.61	0.24
Services	0.06	0.10	0.12	0.19	0.10	0.13	0.11	0.23
	SouthernCoastal				Central			
Agriculture	0.14	0.12	0.01	0.01	0.17	0.29	0.01	0.02
Light	0.11	0.35	0.03	0.06	0.09	0.29	0.04	0.07
Heavy	0.11	0.12	0.59	0.19	0.11	0.08	0.57	0.24
Services	0.10	0.12	0.12	0.22	0.07	0.11	0.15	0.21
	NorthWest				SouthWest			
Agriculture	0.18	0.34	0.01	0.01	0.18	0.27	0.01	0.01
Light	0.07	0.19	0.02	0.05	0.08	0.17	0.02	0.06
Heavy	0.13	0.07	0.50	0.25	0.10	0.09	0.53	0.28
Services	0.10	0.11	0.14	0.19	0.06	0.11	0.15	0.22

Notes: The 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 region.

TABLE E.6
SECTORAL SHARE

Sectoral Share (% of Total)		2002	2007	2015
		Year		
GDP	**Agriculture**	13.64%	10.62%	8.20%
	Light industry	9.34%	8.50%	7.94%
	Heavy industry	30.46%	33.85%	28.77%
	Service	46.57%	47.04%	55.10%
Export	**Agriculture**	1.56%	0.86%	0.70%
	Light industry	22.21%	18.04%	15.82%
	Heavy industry	55.30%	66.08%	65.54%
	Service	20.93%	15.03%	17.93%
Import	**Agriculture**	2.43%	3.10%	3.48%
	Light industry	10.32%	5.26%	6.12%
	Heavy industry	77.01%	80.56%	57.92%
	Service	10.24%	11.08%	32.48%

APPENDIX F: ROBUSTNESS CHECK

F.1. Counterfactual Structural Decomposition under Exogenous Trade Deficit to GDP Ratio

Given that the trade deficit is exogenous to the model, I approach its treatment in two distinct ways within the counterfactual analysis. In the primary analysis, I set the trade deficit to zero. For robustness checks, I perform analogous counterfactual analyses, but with the model incorporating a fixed trade deficit to GDP ratio. Additionally, to ensure algorithmic convergence and maintain a constant world GDP while updating new wage rates, I adjust for the trade deficit of the Rest of the World (ROW) using the equation: $D_{ROW} = \sum_{i=1}^{N} X_{ni} - \sum_{i=1}^{N} X_{in} - \sum_{n \neq ROW} \xi_n w_n L_n$, where ξ_n denotes the deficit to GDP ratio for region n.

In summary, the main text analyzes the model under the assumption of a zero trade deficit across all counterfactual scenarios. Subsequently, similar analyses are conducted with an exogenous trade deficit ratio, with further adjustments made to the ROW deficit to address any excess. The results from these robustness checks corroborate the findings presented in the primary analysis.

Decomposition of change in trade share of GDP under exogenous trade deficit to GDP ratio

TABLE F.1
STRUCTURAL ACCOUNTING DECOMPOSITION UNDER EXOGENOUS TRADE DEFICIT

Marginal effects	2002 to 2007				2007 to 2015			
	Trade Share of GDP change (p.p.)			Real GDP p.c. change (%)	Trade Share of GDP change (p.p.)			Real GDP p.c. change (%)
	Export	Import	Intra.		Export	Import	Intra.	
All forces (Baseline)	**12.0**	**3.9**	**16.4**	**113.7**	**-10.8**	**-10.1**	**3.2**	**167.4**
China's productivity	**-4.6**	**-9.2**	**4.9**	**95.4**	**-14.3**	**-11.9**	**-0.7**	**153.3**
China's labor	**2.9**	**-0.6**	**-0.4**	**2.0**	**-1.5**	**-1.5**	**1.2**	**4.3**
Migration firction	3.2	-0.3	-0.4	2.4	-1.0	-1.2	1.2	4.3
labor supply	-0.4	-0.3	0.1	-0.4	-0.5	-0.4	0.0	0.2
China's trade cost	**5.6**	**6.1**	**12.4**	**6.7**	**-3.1**	**-3.9**	**-4.4**	**-2.2**
Intranational	-1.4	-0.9	14.2	4.2	0.2	-0.6	-3.7	-1.6
International	7.4	7.3	-1.9	2.6	-3.6	-3.7	-1.0	-1.0
Other regions' forces	**4.5**	**4.3**	**-0.5**	**1.3**	**-1.1**	**-1.1**	**2.4**	**-0.7**
Foreign productivity	4.5	4.3	-0.5	1.3	-0.5	-0.5	2.2	-0.5
Foreign trade cost	-0.6	-0.5	0.2	-0.2	-0.8	-0.8	0.3	-0.2
Foreign labor	0.7	0.7	-0.2	0.2	0.5	0.5	-0.1	0.1

Notes: This table decomposes changes in international and intranational trade shares of GDP, as well as real GDP per worker, into contributions from several types of shocks: China's sectoral productivity shocks, China's regional initial labor supply shocks, China's labor mobility cost shocks, China's intranational trade cost shocks, China's international trade cost shocks, and shocks from other regions. The latter category encompasses shocks to foreign economies' sectoral productivity, foreign economies' labor supply, and trade costs between foreign economies. The marginal effects of speciffc types of shocks are calculated by subtracting the value under the scenario where these shocks remain unchanged from the value under the baseline case (where all shocks are realized). Since the model is non-linear, the aggregated marginal effects of individual factors do not necessarily equal the marginal effects of all forces.

Decomposition of change in trade share of GDP at sector level

TABLE F.2

STRUCTURAL ACCOUNTING DECOMPOSITION UNDER EXOGENOUS TRADE DEFICIT

Marginal effects	**2002 to 2007**				**2007 to 2015**			
	Trade Share of GDP change (p.p.)			Real GDP p.c. change (%)	Trade Share of GDP change (p.p.)			Real GDP p.c. change (%)
	Export	Import	Intra.		Export	Import	Intra.	
All Forces (Baseline)	**12.0**	**3.9**	**16.4**	**113.7**	**-10.8**	**-10.1**	**3.2**	**167.4**
Sectoral effects								
China's productivity	**-4.6**	**-9.2**	**4.9**	**95.4**	**-14.3**	**-11.9**	**-0.7**	**153.3**
Agriculture	-2.1	-1.4	0.4	5.0	-1.6	-1.5	-0.6	7.2
Light industry	-0.8	-0.9	0.5	6.4	-0.7	-0.5	-0.4	5.8
Heavy industry	-7.3	-7.7	4.8	21.2	-8.1	-7.8	2.9	33.0
Service	-2.0	-6.0	-0.3	39.9	-14.6	-13.1	-5.8	66.5
China's international trade cost	**7.4**	**7.3**	**-1.9**	**2.6**	**-3.6**	**-3.7**	**-1.0**	**-1.0**
Agriculture	-0.3	-0.3	0.0	-0.1	-1.7	-1.6	-0.1	-0.4
Light industry	0.3	0.3	-0.1	0.3	-0.3	-0.3	0.0	-0.1
Heavy industry	5.6	5.5	-0.7	1.6	-0.9	-0.9	1.0	-0.5
Service	0.5	0.5	-0.8	0.2	-4.3	-4.2	-1.4	-1.1
Interact effects								
China's productivity and trade cost	**3.4**	**-0.6**	**17.0**	**110.8**	**-19.3**	**-17.8**	**-0.9**	**151.5**
All region's productivity and trade cost	**7.9**	**3.6**	**16.7**	**113.1**	**-10.7**	**-9.6**	**2.4**	**156.1**
All region's productivity	1.2	-3.8	4.3	98.5	-12.8	-10.4	2.4	151.6
All region's trade cost	5.4	5.9	12.5	6.6	-2.5	-3.3	-4.1	-2.1

Notes: This table analyzes the changes in China's trade shares of GDP and other variables by attributing them to various factors, such as changes in China's productivity, international trade costs, and intranational trade costs, at a more disaggregated level. Additionally, it examines the interaction of these factors at a more aggregated level. The marginal effects of specific types of shocks are determined by comparing the values under the baseline scenario (where all shocks are realized) with those under a scenario where specific shocks remain unchanged. Since the model is non-linear, the aggregated marginal effects of individual factors do not necessarily equal the marginal effects of all forces.