Structural Change in the Global Economy*

Hayato Kato[†], Kensuke Suzuki[‡], and Motoaki Takahashi[§]

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Abstract

In the last few decades, developed countries have witnessed a significant decline in their manufacturing sectors along with emerging economies being integrated into the global economy. To what extent international trade with emerging economies and innate driving forces within developed countries account for such a decline in manufacturing? To address the question, we develop a quantitative dynamic general equilibrium model of trade with capital accumulation. Our model features nonhomothetic CES preferences popularized by Comin et al. (2021), allowing consumers to present varying income elasticities of demand across sectors. We bring the model to the data for the world economy, encompassing three sectors (agriculture, manufacturing, and services) and 24 countries. We calibrate the model's fundamentals, including trade costs and productivity, and solve the model for transition paths. By applying counterfactual trade costs and productivity levels for different sectors and countries, we discuss how these factors collectively shape structural change and its interaction with international trade in advanced countries. Specifically, our quantitative model suggests that the decline in the value-added share of manufacturing in the US since 2000 is virtually fully attributable to the China shock.

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[†]Graduate School of Economics, Osaka University; CESifo Research Network. Email: hayato.kato.econ@osaka-u.ac.jp

[‡]Department of Economics, Clark University; Economic Research Center, Nagoya University. Email: ksuzuki@clarku.edu

[§]Johannes Gutenberg University Mainz; Kiel Institute for the World Economy. Email: mtakahas@uni-mainz.de

1 Introduction

One of the most heated discussions in the last few decades in academic and policy arenas is the significant impacts of globalization on developed countries. The 1990s witnessed the United States (US) lowering trade barriers against Mexico under the North American Free Trade Agreement (NAFTA). In the 2000s, particularly noteworthy is China's accession to the World Trade Organization (WTO) in 2001. A number of studies find adverse effects of these events on industries in developed economies, in particular, their manufacturing employment. Looking at the impacts of China's growing trade, for example, Acemoglu et al. (2016) report 2.0 to 2.4 million US manufacturing workers losing their jobs due to Chinese import competition over 1999 to 2011.[1] Figure 1 (a) shows the evolution of the manufacturing share in value-added of selected countries over the past five decades, from 1965 to 2014. The sharp drop in US manufacturing is evident after the 2000s, and one may argue this can be largely attributed to the "China shock."

From the viewpoint of long-term economic development, however, the manufacturing sector in developed countries is bound to shrink even if the impacts of international trade are not taken into account. As the nation's income grows, it reallocates resources from agriculture to manufacturing, and then to service in a process known as structural change (Kuznets, 1973; Herrendorf et al., 2014). Figure 1 illustrates this point; manufacturing value-added share in the US and Germany started to decline in the 1960s (Figure 1 (a)), whereas service value-added share steadily increased over time (Figure 1 (b)). Japan and China exhibit a similar pattern with a time lag.

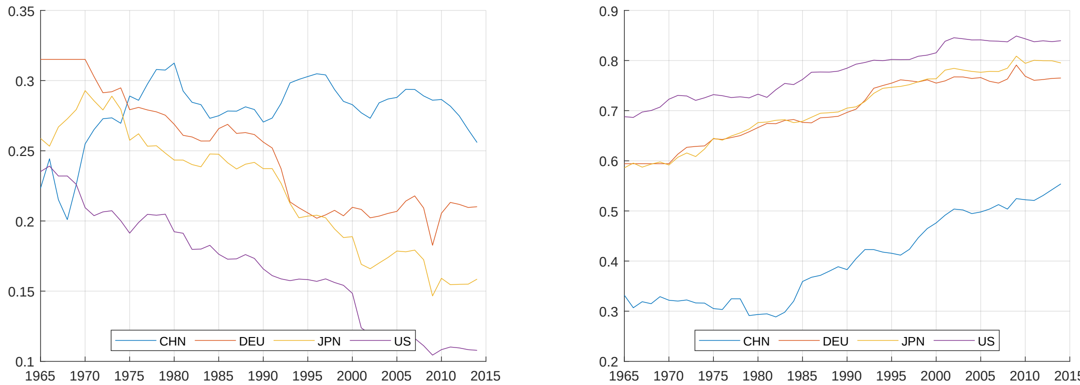
These different views on declining manufacturing in developed countries lead to a number of important questions: What is the role of international trade in determining relative sizes of sectors in developed countries? To what extent can the changes in the manufacturing value-added shares be attributed to trade and other driving forces within developed countries themselves? Was the decline in manufacturing inevitable even without the China shock?

To answer these questions, we propose a unified framework of trade, structural change, and endogenous capital accumulation. We model trade based on the Ricardian comparative advantage *à la* Eaton and Kortum (2002); Caliendo and Parro (2015) and also highlight two prominent drivers of structural change pointed out in the literature: the Baumol effect and the income effect (see for Acemoglu, 2008, Ch.20 a survey). The Baumol effect refers to the substitution of production due to changes in relative prices associated with sector-biased technological change (Baumol, 1967; Ngai and Pissarides, 2007). We capture this by

[1] See also Autor et al. (2013); Acemoglu et al. (2016); Pierce and Schott (2016). The adverse effects of rising Chinese imports are observed in other developed countries, including Canada (Albouy et al., 2019), Denmark (Utar, 2018), France (Malgouyres, 2017), and Germany (Dauth et al., 2014). See also Autor et al. (2016) for a comprehensive review. We note, however, that not all studies find negative effects of rising Chinese imports on developed countries. Taniguchi (2019), for example, finds a positive effect of the China shock in Japan due to the complementary role of imported intermediate inputs.

Figure 1: Value Added Share in GDP

(a) Manufacturing (b) Service



Notes: The data is from the WIOD database. See Section 4 for details.

allowing sector-biased technological change and changes in the composition of sectoral inputs in production and investment as in García-Santana et al. (2021); Herrendorf et al. (2021). On the other hand, the income effect emphasizes non-homothetic preferences such that, as income grows, consumers shift their expenditure from less-income-elastic goods such as food to more-income-elastic goods such as services (Kongsamut et al., 2001). Our model employs nonhomothetic CES preferences as in Hanoch (1975); Matsuyama (2019); Comin et al. (2021).[2] Finally, we model forward-looking decisions on capital investment as in Eaton et al. (2016); Ravikumar et al. (2019).

We calibrate our model using the data for 24 countries over half the century, from 1965 to 2014. We calibrate the model's fundamentals, such as sectoral productivity and trade costs, which allows us to solve transition paths of the economy in terms of *level*, not in *relative change* known as the hat-algebra method (Dekle et al., 2008; Caliendo and Parro, 2015; Caliendo et al., 2019). We then conduct a counterfactual analysis to examine the role of international trade in shaping the industrial structure of advanced economies.

Specifically, among other counterfactual experiments, we ask what the sectoral composition of the economy would look like if the productivity of China and the trade costs between China and the other countries did not change since 1999. This counterfactual experiment teases out the effect of the China shock on the industry composition across developed countries. The China shock has heterogeneous impacts on the valued-added shares of manufacturing across countries. In Germany and the United States, for example, the counterfactual (no-China-shock)

[2]Unlike more standard classes of preferences such as the Stone-Geary, the nonhomothetic CES preference shows non-vanishing non-unitary income elasticities as income grows, which is consistent with the empirical finding of Comin et al. (2021), while maintaining analytical tractability as much as possible.

manufacturing shares are higher than the baseline ones by about 2% points and 7% points, respectively, in 2005. In contrast, in Japan, the counterfactual manufacturing share is actually lower than the baseline one by about 2% points in the year. Put differently, the China shock reduced manufacturing in the US and Germany, while it retained manufacturing in Japan. Our counterfactual predictions imply that international trade with China played a big role in accelerating the shift from manufacturing to service in some advanced countries like the US and Germany. That is, traditional structural change forces operated in closed economies, i.e., the income effect and the Bamoul effect, alone cannot explain the rapid deindustrialization at least in the US and Germany. Our predictions also align with results from empirical studies such as Autor et al. (2013) and Taniguchi (2019).

Our study is positioned in the recent literature on quantitative models of structural change embedding international trade (see Alessandria et al., 2023 for a survey). Those studies show a number of new insights such as the decomposition of different mechanisms for declining manufacturing share (Święcki, 2017; Smitkova, 2023), a systematic relationship between countries' intermediate-input intensities and their level of development (Sposi, 2019), and the negative effect of structural change on trade (Lewis et al., 2022). In modeling international trade, these studies follow static models of Eaton and Kortum (2002) and Caliendo and Parro (2015).

Unlike those studies, we propose a dynamic model with endogenous capital accumulation *à la* Eaton et al. (2016) and Ravikumar et al. (2019), which allows us to explain the evolution of sectoral production as endogenous outcomes rather than calibration results. This is far from a trivial extension since recent studies in the closed-economy context emphasize the role of investment (e.g., Herrendorf et al., 2014, Sec. 6.3.3) in shaping the industrial structure of the economy. Moreover, our model can speak to the dynamics of trade balance and how this interacts with structural change (Kehoe et al., 2018).

Our paper is most closely related to Sposi et al. (2021), which develops and applies the dynamic model of international trade to study structural change.[3] Despite the similarity in the analytical framework, we have a different set of questions. Sposi et al. (2021) focus on the recent empirical finding of "premature deindustrialization," which conceptualizes that developing countries today experience the transition from manufacturing to service much earlier than those several decades ago (Rodrik, 2016). Furthermore, they also show new evidence that the cross-country dispersion of manufacturing share has increased over time. Our paper contrasts with their study by emphasizing more country- and region-specific episodes

[3] Another closely related study is Święcki (2017) examining to what extent each elements of the model contributes to changes in sectoral composition. He finds that the most important element is the sector-biased productivity. We depart from his static model with non-tradable services by allowing for endogenous capital accumulation and tradable services. His finding might be due to his calibration based on the model without capital, because the estimates of sector-biased sectoral productivity potentially include the contribution by capital. We instead model capital explicitly and give more precise estimates of productivities.

of globalization, specifically the effects of the China shock on the industry structure across developed countries. (In the future, we plan to evaluate the welfare effects of these episodes by measuring the equivalent variation of trade shocks and provide a novel decomposition into the terms of trade effect and other effects in an analytical form. We will then attempt to quantitatively evaluate each effect and investigate if there are systematic relationships between welfare effects and shifts in sectoral expenditure/production.)

The remainder of this paper is structured as follows: section 2 presents the model, section 3 discusses qualitative results of the model, section 4 introduces the calibration of the model and solution algorithm, section 5 presents the quantitative results, and section 6 concludes.

2 Model

We consider a dynamic economy in which time is descrete $t = 0, 1, \cdots$. The set of countries is $\mathcal{N} = \{1, 2, \cdots, N\}$. Thus the cardinality of $\mathcal{N}$ is N. Countries are generically indexed by i or n. There are three sectors: agriculture, manufacturing, and services. Sectors are generically intexed by $j = a, m, s$, where a, m, and s stand for agriculture, manufacturing, and services, respectively. Sectors and industries are synonymous in this paper.

The representative household in country n as of period 0 maximizes the lifetime utility function

$$\sum_{t=0}^{\infty} \beta^t \zeta_{n,t} L_{n,t} \frac{(C_{n,t}/L_{n,t})^{1-\psi}}{1-\psi} \tag{1}$$

where $\beta \in (0, 1)$ is the discount factor, $\psi > 1$ is the intertemporal elasticity of substitution, $\zeta_{n,t}$ is the demand shifter in country n and period t, and $L_{n,t}$ is the population of country n and period t. The aggregate consumption in country n and period t, $C_{n,t}$, is *implicitly* defined by

$$\sum_{j=a,m,s} (\Omega^j)^{\frac{1}{\sigma}} \left(\frac{C_{n,t}}{L_{n,t}}\right)^{\frac{\epsilon^j (1-\sigma)}{\sigma}} \left(\frac{C^j_{n,t}}{L_{n,t}}\right)^{\frac{\sigma-1}{\sigma}} = 1, \tag{2}$$

where, for $j = a, m, s$, $C^j_{n,t}$ is the composite good of sector j which the representative household in country n and period t consumes, Ω^j is the demand shifter for sector j, ϵ^j is the parameter governing how the period utility changes as the composite good of sector j changes (nonhomotheticity), and σ is the (intratemporal) elasticity of substituion across the sectoral composite goods. The period utility function (2) follows Hanoch (1975) and Comin et al. (2021). Following Eaton and Kortum (2002), we assume that a unit continuum of varieties exists in each sector. For $j = a, m, s$, the composite good of sector j which country n consumes in period t is defined to be

$$C^j_{n,t} = \left[\int_0^1 C^j_{n,t}(z)^{\frac{\eta-1}{\eta}} dz\right]^{\frac{\eta}{\eta-1}}, \tag{3}$$

where η is the elasticity of substitution across varieties within sectors.

Solving the intratemporal expenditure minimization problem given $C_{n,t}$, the expenditure of country n in period t is

$$E_{n,t} = L_{n,t} \left[\sum_{j=a,m,s} \Omega_{n,t}^{j} \left\{ \left(\frac{C_{n,t}}{L_{n,t}} \right)^{\epsilon^j} P_{n,t}^{j} \right\}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{4}$$

where $P_{n,t}^{j}$ is the price of the composite good of sector j in country n and period t. Define $P_{n,t}$ by $P_{n,t} = E_{n,t}/C_{n,t}$. Then we have

$$P_{n,t} = \left[\sum_{j=a,m,s} \Omega_{n,t}^{j} (P_{n,t}^{j})^{1-\sigma} \left(\frac{C_{n,t}}{L_{n,t}} \right)^{(1-\sigma)(\epsilon^j-1)} \right]^{\frac{1}{1-\sigma}}.$$

The consumption of the composite good of sector j is

$$C_{n,t}^{j} = L_{n,t} \Omega_{n,t}^{j} \left(\frac{P_{n,t}^{j}}{P_{n,t}} \right)^{-\sigma} \left(\frac{C_{n,t}}{L_{n,t}} \right)^{(1-\sigma)\epsilon^j+\sigma}.$$

Let $\omega_{n,t}^{j}$ be country n's expenditure share on sector j in period t, that is, $\omega_{n,t}^{j} = E_{n,t}^{j}/E_{n,t}$, where $E_{n,t}^{j}$ denotes country n's expenditure on sector j goods (or services) in period t. Then we have

$$\omega_{n,t}^{j} = \frac{\Omega_{n,t}^{j} \left\{ \left(\frac{C_{n,t}}{L_{n,t}} \right)^{\epsilon^j} P_{n,t}^{j} \right\}^{1-\sigma}}{\sum_{j'=a,m,s} \Omega_{n,t}^{j'} \left\{ \left(\frac{C_{n,t}}{L_{n,t}} \right)^{\epsilon^{j'}} P_{n,t}^{j'} \right\}^{1-\sigma}}, \tag{5}$$

and

$$\frac{\omega_{n,t}^{j'}}{\omega_{n,t}^{j}} = \left(\frac{P_{n,t}^{j'}}{P_{n,t}^{j}} \right)^{1-\sigma} \left(\frac{C_{n,t}}{L_{n,t}} \right)^{(1-\sigma)(\epsilon_{j'}-\epsilon_j)} \left(\frac{\Omega^{j'}}{\Omega^{j}} \right).$$

By definition, $\sum_{j=a,m,s} \omega_{n,t}^{j} = 1$. See Comin et al. (2021) for detailed derivations of (4) and (5).

Using these results, we can make clear the role of nonhomotheticity parameter ϵ^j by looking at sector j's sectoral demand elasticity:

$$e_{n,t}^{j} \equiv \frac{\partial \ln C_{n,t}^{j}}{\partial \ln E_{n,t}} = \sigma + (1-\sigma) \frac{\epsilon^j}{\bar{\epsilon}_{n,t}},$$

where

$$\bar{\epsilon}_{n,t} = \sum_{h=a,m,s} \omega_{n,t}^{h} \epsilon^{h}, \tag{6}$$

and the representative household perceives the sectoral price index as given, $\partial \ln P^j_{n,t}/\partial E_{n,t} = 0$.[4] If $\epsilon^j = 0$ for all sector j, the preferences reduce to the standard CES and the sectoral demand elasticity equals σ. As we calibrate later, our interest is in the range of parameters satisfying $\sigma \in (0,1)$ and $0 < \epsilon^a < \epsilon^m < \epsilon^s$. In this case, one can easily check the elasticity is negative in agriculture, $e^a_{n,t} < 0$; positive in services, $e^s_{n,t} > 0$; and can be positive or negative in manufacturing, $e^m_{n,t} \gtrless 0$. That is, along with growing total expenditure, the demand composition shifts from sectors with low ϵ^j to those with high ϵ^j.

The representative household in country n is the sole owner of labor and capital there. The budget constraint of country n in period t is

$$E_{n,t} + P^K_{n,t} I_{n,t} \leq (1-\phi_{n,t}) \left(w_{n,t} L_{n,t} + r_{n,t} K_{n,t} + \widetilde{T}_{n,t} \right) + L_{n,t} T^P_t, \tag{7}$$

where $P^K_{n,t}$ is the capital good price index which will be defined later, $I_{n,t}$ is the quantity of investment, $\phi_{n,t}$ is the fraction of the aggregate income accrued to the global portfolio, and T^P_t is the payment from the global portfolio to each person of country n in period t, and $\widetilde{T}_{n,t}$ is the tariff revenues in country n and period t. $\phi_{n,t}$ is an exogenous parameter.

Let $K_{n,t}$ be the quantity of capital in country n and period t. Then capital dynamics are

$$K_{n,t+1} = (1-\delta_{n,t}) K_{n,t} + I^\lambda_{n,t} (\delta_{n,t} K_{n,t})^{1-\lambda}, \tag{8}$$

where $\delta_{n,t}$ is the capital depreciation rate in country n and period t and $\lambda \in [0,1]$ is a parameter governing capital adjustment costs. Solving this for $I_{n,t}$ and viewing it as a function of $K_{n,t}$, $K_{n,t+1}$, and $\delta_{n,t}$, we have

$$I_{n,t} = \Phi(K_{n,t+1}, K_{n,t}; \delta_{n,t}) = \delta_{n,t}^{1-\frac{1}{\lambda}} K_{n,t} \left(\frac{K_{n,t+1}}{K_{n,t}} - (1-\delta_{n,t}) \right)^{\frac{1}{\lambda}}.$$

Take the derivatives of Φ with respect to the first and the second argument

$$\Phi_1(K_{n,t+1}, K_{n,t}; \delta_{n,t}) = \frac{\partial \Phi}{\partial K_{n,t+1}} (K_{n,t+1}, K_{n,t}; \delta_{n,t}) = \frac{1}{\lambda} \delta_{n,t}^{1-\frac{1}{\lambda}} \left(\frac{K_{n,t+1}}{K_{n,t}} - (1-\delta_{n,t}) \right)^{\frac{1}{\lambda}-1},$$

$$\Phi_2(K_{n,t+1}, K_{n,t}; \delta_{n,t}) = \frac{\partial \Phi}{\partial K_{n,t}} (K_{n,t+1}, K_{n,t}; \delta_{n,t}) = \Phi_1(K_{n,t+1}, K_{n,t}; \delta_{n,t}) \cdot \left((\lambda - 1) \frac{K_{n,t+1}}{K_{n,t}} - \lambda (1-\delta_{n,t}) \right).$$

The dynamic optimization problem of the representative household in country n and period 0 is

max (1)

[4]In this case, the sectoral demand elasticity equals the sectoral expenditure elasticity, $e^j_{n,t} = \frac{\partial \ln (P^j_{n,t} C^j_{n,t})}{\partial E_{n,t}}$.

subject to (4), (7), and (8). Solving this problem, we obtain the Euler equation

$$\left(\frac{C_{n,t+1}/L_{n,t+1}}{C_{n,t}/L_{n,t}}\right)^{\psi-1} \frac{E_{n,t+1}\bar{\epsilon}_{n,t+1}}{E_{n,t}\bar{\epsilon}_{n,t}} = \beta \frac{\zeta_{n,t+1}}{\zeta_{n,t}} \frac{L_{n,t+1}}{L_{n,t}} \frac{(1-\phi_{n,t+1})r_{n,t+1} - P^K_{n,t+1}\Phi_2(K_{n,t+2}, K_{n,t+1}; \delta_{n,t+1})}{P^K_{n,t}\Phi_1(K_{n,t+1}, K_{n,t}; \delta_{n,t})}. \tag{9}$$

Both $E_{n,t+1}/E_{n,t}$ and $\bar{\epsilon}_{n,t+1}/\bar{\epsilon}_{n,t}$ are both increasing in $\frac{C_{n,t+1}/L_{n,t+1}}{C_{n,t}/L_{n,t}}$. Since $\psi > 1$, therefore, the left-hand side is just an increasing function of the ratio in per-capita consumption between periods $t+1$ and t. Eq. (9) tells that this per-capita consumption ratio depends on the discount factor (β), the ratio in the intertemporal demand shifters ($\zeta_{n,t+1}/\zeta_{n,t}$), the ratio in populations ($L_{n,t+1}/L_{n,t}$), and the real return to capital

$$\frac{(1-\phi_{n,t+1})r_{n,t+1} - P^K_{n,t+1}\Phi_2(K_{n,t+2}, K_{n,t+1}; \delta_{n,t+1})}{P^K_{n,t}\Phi_1(K_{n,t+1}, K_{n,t}; \delta_{n,t})}.$$

We have described households' behavior thus far. We move on to producers' behavior. The production function of variety $z \in [0,1]$ of sector j in country n and period t is

$$y^j_{n,t}(z) = a^j_{n,t}(z) \left(\frac{K^j_{n,t}(z)}{\gamma^j_{n,t}\alpha^j_{n,t}}\right)^{\gamma^j_{n,t}\alpha^j_{n,t}} \left(\frac{L^j_{n,t}(z)}{\gamma^j_{n,t}(1-\alpha^j_{n,t})}\right)^{\gamma^j_{n,t}(1-\alpha^j_{n,t})} \left(\frac{M^j_{n,t}(z)}{1-\gamma^j_{n,t}}\right)^{1-\gamma^j_{n,t}}. \tag{10}$$

Here $y^j_{n,t}(z)$ is the quantity of output, $a^j_{n,t}(z)$ is the productivity which will be expressed as a realization of a random variable, $K^j_{n,t}(z)$ is the capital, $L^j_{n,t}(z)$ is the labor, $\gamma^j_{n,t} \in (0,1)$ is the value-added share, that is, the cost share on production factors (labor and capital), not on intermediate inputs, $\alpha^j_{n,t} \in (0,1)$ is the cost share on capital *within production factors*, $M^j_{n,t}(z)$ is the CES aggregate of sectoral intermediate goods used for production of variety z, that is,

$$M^j_{n,t}(z) = \left(\sum_{j'=a,m,s} (\kappa^{j,j'}_{n,t})^{\frac{1}{\sigma^j}} (M^{j,j'}_{n,t}(z))^{\frac{\sigma^j-1}{\sigma^j}}\right)^{\frac{\sigma^j}{\sigma^j-1}},$$

where $\kappa^{j,j'}_{n,t}$ is the shifter for sector j's demand for sector-j' goods, $M^{j,j'}_{n,t}(z)$ is the input of sector-j' good for production of variety z of sector j and is produced using the same CES composite in (3), and σ^j is the elasticity of substitution across sectoral goods for production of sector j goods. In production of sector-j goods, the cost share on sector-j' goods *within intermediate-good costs* is

$$g^{j,j'}_{n,t} = \frac{P^{j'}_{n,t}M^{j,j'}_{n,t}}{\sum_{j''=a,m,s} P^{j''}_{n,t}M^{j,j''}_{n,t}} = \frac{\kappa^{j,j'}_{n,t}(P^{j'}_{n,t})^{1-\sigma^j}}{\sum_{j''=a,m,s} \kappa^{j,j''}_{n,t}(P^{j''}_{n,t})^{1-\sigma^j}}.$$

The productivity of variety z of sector j in country n and period t, $a^j_{n,t}$, follows the Frechét distribution whose the probability distribution function is

$$F_{n,t}^j(a) = \Pr[a_{n,t}^j \le a] = \exp\left[-\left(\frac{a}{\widetilde{\gamma}^j A_{n,t}^j}\right)^{-\theta^j}\right].$$

Here θ^j and $A_{n,t}^j$ are the shape parameter and the location parameter of the Frechét distribution, respectively, and $\widetilde{\gamma}^j = [\Gamma((\theta^j + 1 - \eta)/\theta^j)]^{\frac{-1}{1-\eta}}$ is a country-specific normalizing constant, where $\Gamma(\cdot)$ is the Gamma function. Productivity of varieties are independent within and across sectors, countries, and periods.

Solving the cost minimization problem for the production function (10), the cost for an input bundle is

$$\widetilde{c}_{n,t}^j = (r_{n,t})^{\gamma_{n,t}^j \alpha_{n,t}^j} (w_{n,t})^{\gamma_{n,t}^j (1-\alpha_{n,t}^j)} (\xi_{n,t}^j)^{1-\gamma_{n,t}^j}, \tag{11}$$

where $\xi_{n,t}^j$ is the CES price index for the composite intermediate good for production of sector-j goods

$$\xi_{n,t}^j = \left[\sum_{j'=a,m,s} \kappa_{n,t}^{j,j'} (P_{n,t}^{j'})^{1-\sigma^j}\right]^{\frac{1}{1-\sigma^j}}. \tag{12}$$

The price index (or the price of the composite good) of sector j in country n and period t is

$$P_{n,t}^j = \left[\sum_{i \in \mathcal{N}} \left(\frac{\tilde{c}_{i,t}^j b_{ni,t}^j}{A_{i,t}^j}\right)^{-\theta^j}\right]^{-1/\theta^j}, \tag{13}$$

where $b_{ni,t}^j$ is the total trade costs including tariffs and non-tariff trade barriers for goods or services of sector j from country i to country n. $b_{ni,t}^j$ is expressed as

$$b_{ni,t}^j = d_{ni,t}^j (1 + \tau_{ni,t}^j),$$

where $d_{ni,t}^j$ is the iceberg trade cost for sector-j goods from country i to country n in period t including phisical trade costs and non-tariff barriers, and $\tau_{ni,t}^j$ is country n's tariffs against sector-j goods from country i in period t. For later use, define gross tariffs $\tilde{\tau}_{ni,t}^j$ by $\tilde{\tau}_{ni,t}^j = 1 + \tau_{ni,t}^j$.

The production function of capital (investment) goods in country n and period t is

$$I_{n,t} = \kappa_{n,t}^K \left(\sum_{j=a,m,s} (\kappa_{n,t}^{K,j})^{\frac{1}{\sigma^K}} (M_{n,t}^{K,j})^{\frac{\sigma^K - 1}{\sigma^K}}\right)^{\frac{\sigma^K}{\sigma^K - 1}}, \tag{14}$$

where $\kappa_{n,t}^K$ is the productivity, $M_{n,t}^{K,j}$ is the sector-j goods used for production of capital goods, and σ^K is the elasticity of substitution across sectoral intermediate goods for production of capital goods. Then the cost share on sector-j goods

$$g_{n,t}^{K,j} = \frac{P_{n,t}^{j} M_{n,t}^{K,j}}{\sum_{j'=a,m,s} P_{n,t}^{j'} M_{n,t}^{K,j'}} = \frac{\kappa_{n,t}^{K,j} (P_{n,t}^{j})^{1-\sigma^K}}{\sum_{j'=a,m,s} \kappa_{n,t}^{K,j'} (P_{n,t}^{j'})^{1-\sigma^K}}.$$

The ideal price index of capital goods is

$$P_{n,t}^{K} = \frac{1}{\kappa_{n,t}^{K}} \left(\sum_{j=s,m,s} \kappa_{n,t}^{K,j} (P_{n,t}^{j})^{1-\sigma^K} \right)^{\frac{1}{1-\sigma^K}}.$$

Let $X_{ni,t}^{j}$ be country n's spending on sector-j goods (or services) from country i in period t. This includes spending for consumption, investment, and intermediate inputs. Summing $X_{ni,t}^{j}$ across i, let $X_{n,t}^{j}$ be country n's spending on sector j goods (or services) in period t. Let $\pi_{ni,t}^{j} = X_{ni,t}^{j}/X_{n,t}^{j}$, that is, the share of goods from country i within country n's expenditure on sector j goods in period t. We call $\pi_{ni,t}^{j}$ as trade shares following the literature of quantitative trade models. Following Eaton and Kortum (2002), we have

$$\pi_{ni,t}^{j} = \frac{(\tilde{c}_{i,t}^{j} b_{ni,t}^{j} / A_{i,t}^{j})^{-\theta^j}}{\sum_{i' \in \mathcal{N}} (\tilde{c}_{i',t}^{j} b_{ni',t}^{j} / A_{i',t}^{j})^{-\theta^j}} = \frac{(\tilde{c}_{i,t}^{j} b_{ni,t}^{j} / A_{i,t}^{j})^{-\theta^j}}{(P_{n,t}^{j})^{-\theta^j}} \tag{15}$$

Let $Y_{n,t}^{j}$ be the gross production of sector j in country n and period t. It is value not quantity. We have

$$Y_{n,t}^{j} = \sum_{i \in \mathcal{N}} \frac{\pi_{in,t}^{j}}{\tilde{\tau}_{in,t}^{j}} X_{i,t}^{j}. \tag{16}$$

Country n's spending on sector-j goods in period t consists of the final consumption, the input for production of capital goods, and the input for production of goods and services of various sectors

$$\begin{aligned} X_{n,t}^{j} &= P_{n,t}^{j} C_{n,t}^{j} + P_{n,t}^{j} M_{n}^{K,j} + \sum_{j'=a,m,s} (1-\gamma_{n,t}^{j'}) g_{n,t}^{j',j} Y_{n,t}^{j'} \\ &= \omega_{n,t}^{j} E_{n,t} + + g_{n,t}^{K,j} P_{n,t}^{K} I_{n,t} + \sum_{j'=a,m,s} (1-\gamma_{n,t}^{j'}) g_{n,t}^{j',j} Y_{n,t}^{j'}. \end{aligned} \tag{17}$$

In country n and period t, the aggregate labor income must be equal to the aggregate labor cost

$$w_{n,t} L_{n,t} = \sum_{j=a,m,s} \gamma_{n,t}^{j} (1-\alpha_{n,t}^{j}) Y_{n,t}^{j}. \tag{18}$$

Similarly, the aggregate capital income must be equal to the aggregate capital cost

$$r_{n,t}K_{n,t} = \sum_{j=a,m,s} \gamma_{n,t}^j \alpha_{n,t}^j Y_{n,t}^j. \tag{19}$$

The trade deficit, $D_{n,t}$, is the imports minus the exports

$$D_{n,t} = \underbrace{\sum_{j=a,m,s}\sum_{i=1}^{N} X_{n,t}^j \frac{\pi_{ni,t}^j}{\tilde{\tau}_{ni,t}^j}}_{\text{imports}} - \underbrace{\sum_{j=a,m,s}\sum_{i=1}^{N} X_{i,t}^j \frac{\pi_{in,t}^j}{\tilde{\tau}_{in,t}^j}}_{\text{exports}}.$$

Country n's trade deficit must be equal to its net payment to the global portfolio

$$D_{n,t} = L_{n,t}T_t^P - \phi_{n,t}(w_{n,t}L_{n,t} + r_{n,t}K_{n,t} + \widetilde{T}_{n,t}).$$

We move on to the budget balance of the global portfolio. The sum of the net payments from all countries to the global portfolio must be zero

$$\sum_{n=1}^{N} \left\{ \phi_{n,t}(w_{n,t}L_{n,t} + r_{n,t}K_{n,t} + \widetilde{T}_{n,t}) - L_{n,t}T_t^P \right\} = 0.$$

Solving this for T_t^P, we have

$$T_t^P = \frac{\sum_{n=1}^{N} \phi_{n,t}(w_{n,t}L_{n,t} + r_{n,t}K_{n,t} + \widetilde{T}_{n,t})}{\sum_{n=1}^{N} L_{n,t}}. \tag{20}$$

Definition 1 (Equilibrium)**.** Given the capital stocks in the initial period $\{K_{n,0}\}_{n\in\mathcal{N}}$, an equilibrium is a tuple of $\{w_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{r_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{E_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{\tilde{c}_{n,t}^j\}_{n\in\mathcal{N},t=0,\cdots,\infty,j=a,m,s}$, $\{P_{n,t}^j\}_{n\in\mathcal{N},t=0,\cdots,\infty,j=a,m,s}$, $\{\pi_{ni,t}^j\}_{(n,i)\in\mathcal{N}\times\mathcal{N},t=0,\cdots,\infty,j=a,m,s}$, $\{Y_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{X_{n,t}^j\}_{n\in\mathcal{N},t=0,\cdots,\infty,j=a,m,s}$, $\{\bar{\epsilon}_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{\omega_{n,t}^j\}_{n\in\mathcal{N},t=0,\cdots,\infty,j=a,m,s}$, $\{C_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{K_{n,t}\}_{n\in\mathcal{N},t=1,\cdots,\infty}$, $\{I_{n,t}\}_{n\in\mathcal{N},t=0,\cdots,\infty}$, $\{T_t^P\}_{t=0,\cdots,\infty}$ satisfying a system of equations (4), (5), (7), (8), (9), (6), (11), (13), (15), (16), (17), (18), (19), and (20).

We compute transition paths, that is, equilibria converging to steady states. For this purpose, we define steady states of this model.

Definition 2 (Steady state)**.** A steady state is an equilibrium in which relevant endogenous variables are time-invariant. Specifically, a steady state is a tuple of $\{w_n\}_{n\in\mathcal{N}}$, $\{r_n\}_{n\in\mathcal{N}}$, $\{E_n\}_{n\in\mathcal{N}}$, $\{\tilde{c}_n^j\}_{n\in\mathcal{N},j=a,m,s}$, $\{P_n^j\}_{n\in\mathcal{N},j=a,m,s}$, $\{\pi_{ni}^j\}_{(n,i)\in\mathcal{N}\times\mathcal{N},j=a,m,s}$, $\{Y_n\}_{n\in\mathcal{N}}$, $\{X_n^j\}_{n\in\mathcal{N},j=a,m,s}$, $\{\omega_n^j\}_{n\in\mathcal{N},j=a,m,s}$, $\{C_n\}_{n\in\mathcal{N}}$, $\{K_n\}_{n\in\mathcal{N}}$ satisfying a system of equations (18), (4), (11), (13), (15), (16), (17), (5), (20),

$$r_n K_n = \frac{\alpha}{1-\alpha} w_n L_n,$$

$$r_n = \frac{1-\beta(1-\lambda\delta_n)}{\beta(1-\phi_n)\lambda} P_n^K,$$

and

$$E_n = (1-\phi_n)\left(w_n L_n + r_n K_n + \widetilde{T}_n\right) - \delta_n P_n^K K_n + L_n T^P,$$

dropping time subscripts t from all the equations.

3 Qualitative Results

Before examining quantitative implications, we qualitatively show how different mechanisms shape the reallocation of economic activities across sectors, in particular, changes in sectoral expenditure share and sectoral value-added share.

3.1 Mechanisms for Structural Change

3.1.1 Two-country case without capital accumulation and input-output linkages

Let us consider the simplest possible model of structural change with trade. It is essentially a Dornbusch et al. (1977)'s model with nonhomothetic CES preferences. The economy is static and has two countries, three sectors, and one factor, i.e., labor. We also assume balanced trade, no tariffs, and the Cobb-Douglas composite consumption index in each sector.[5]

The value-added share of sector j in country 1, gdp_1^j, is given by the ratio of value-added of workers in sector j, $VA_1^j = w_1 L_1^j$, to aggregate value-added (or GDP), $VA_1 = \sum_{j=a,m,s} VA_1^j = w_1 L_1$.[6] This can be decomposed into the contributions of the consumption and the net exports:

$$va_1^j = \frac{VA_1^j}{VA_1} = \underbrace{\frac{P_1^j C_i^j}{VA_1}}_{\text{Expenditure}} + \underbrace{\frac{NX_1^j}{VA_1}}_{\text{Trade}},$$

where $NX_1^j \equiv \pi_{21}^j P_2^j C_2^j - \pi_{12}^j P_1^j C_1^j$ is the net export value of country 1 to 2 in sector j, $P_1^j C_1^j / VA_1 \equiv \omega_1^j$ is country 1's expenditure on sector-j goods relative to the country's total value-added, and NX_1^j / VA_1 is country 1's net export of sector-j goods relative to the country's

[5] The last assumption implies that the sector j's consumption index in country 1 is

$$C_1^j = \exp\left(\int_0^1 \ln C_1^j(z) dz\right).$$

This is identical with (3) at $\eta \to 1$.

[6] Since there is no capital (depreciation), the definitions of (net) value-added and the gross value-added are the same.

total value-added. We specify the productivity of variety z in sector j in each country as $a_1^j(z) = A_1^j z^{-\frac{1}{\theta^j}}$ and $a_2^j(z) = A_2^j(1-z)^{-\frac{1}{\theta^j}}$ to be consistent with our quantifiable model. Then the sector j's trade share of country 1 in country 2 is

$$\pi_{21}^j = 1 - \pi_{22}^j = \frac{1}{1 + \left(\dfrac{d_{21}^j w_1/A_1^j}{w_2/A_2^j}\right)^{\theta^j}},$$

and the sector j's trade share of country 2 in country 1, π_{12}^j, is analogously expressed. It is convenient to think of $d_{21}^j w_1/A_1^j$ as an average price for sector j varieties exported from 1 to 2 and w_2/A_2^j as an average price for those produced and consumed in 2 (Chor, 2010). Country 1's trade share in 2 is greater as its relative price is smaller (low $\frac{d_{21}^j w_1/A_1^j}{w_2/A_2^j}$) and the productivity distribution is more dispersed (low θ^j).

To see the determinants of sectoral value-added share more clearly, we derive its logarithmic change as

$$\begin{aligned}
d\ln va_1^j &= \underbrace{\frac{P_1^j C_1^j}{VA_1^j} d\ln\left(\frac{P_1^j C_1^j}{VA_1}\right)}_{\text{Expenditure effect}} + \underbrace{\frac{NX_1^j}{VA_1^j} d\ln\left(\frac{NX_1^j}{VA_1}\right)}_{\text{Trade effect}} \\
&= \underbrace{\underbrace{(1-\sigma)\frac{P_1^j C_1^j}{VA_1^j}\left(d\ln P_1^j - \sum_{h=a,m,s}\omega_1^h d\ln P_1^h\right)}_{\text{Baumol effect}} + \underbrace{(1-\sigma)\frac{P_1^j C_1^j}{VA_1^j}\left(\epsilon^j - \sum_{h=a,m,s}\omega_1^h \epsilon^h\right) d\ln\left(\frac{C_1}{L_1}\right)}_{\text{Income effect}}}_{\text{Expenditure effect}} \\
&\quad + \underbrace{\frac{NX_1^j}{VA_1^j}\left[\frac{w_1 L_1 - NX_1^j}{w_1 L_1} d\ln(NX_1^j) - \sum_{h=a,s}\frac{NX_1^h}{VA_1} d\ln(NX_1^h) - \sum_{h=a,m,s}\omega_1^h d\ln(P_1^h C_1^h)\right]}_{\text{Trade effect}},
\end{aligned} \tag{21}$$

noting that $VA_1^j = w_1 L_1^j$ and $VA_1 = \sum_{j=a,m,s} VA_1^j = w_1 L_1$.

Changes in sector j's value-added share are decomposed into those in expenditure and trade in the first line. If there were no trade, the trade effect disappears and the sectoral value-added share coincides with the sectoral expenditure share, i.e., $va_1^j = \omega_1^j$ and $d\ln va_1^j = d\ln \omega_1^j$.

Closed economy with sector-unbiased technological change Suppose that trade costs are prohibitively high, $d_{ni}^j = \infty$. Then only the expenditure effect operates and can be further decomposed into the two structural forces, the Baumol effect and the income effect. Consider a proportional increase in sectoral productivity, $d\ln A_1^a = d\ln A_1^m = d\ln A_1^s > 0$. This reduces the sectoral price indices proportionally, $d\ln P_1^a = d\ln P_1^m = d\ln P_1^s < 0$,[7] and thus raises the real consumption per capita, $d\ln(C_1/L_1) > 0$ (see the expenditure function (4)). In this case, the Baumol effect vanishes and only the income effect works. Given the parameter choice such that $\epsilon^a < \epsilon^m < \epsilon^s$ and $\sigma \in (0, 1)$, the income effect is negative for agriculture and positive for service. The income effect is mixed for manufacturing: it is positive (or negative) if the agricultural expenditure share ω_1^a (or service expenditure share ω_1^s) is large enough.[8] We can say that in advanced economies with already a high service expenditure share, the income effect works in a way that reduces manufacturing expenditure further.

Closed economy with sector-biased technological change Suppose that the economy is still in autarky, but the sectoral productivity increases are biased towards the manufacturing sector, $d\ln A_1^m > d\ln A_1^a = d\ln A_1^s > 0$, as has been observed in advanced economies (e.g., Sposi et al., 2021). Then the price index in manufacturing declines disproportionately more than in the other sectors, $d\ln P_1^m < d\ln P_1^a = d\ln P_1^s < 0$. The Baumol effect now operates in a way that shifts expenditure from relatively low-priced sectors to high-priced ones. That is, the manufacturing expenditure share declines, while the expenditure share in the other sectors rises.[9]

To summarize the structural change forces in advanced economies under autarky, both the Baumol and the income effects cause their manufacturing value-added share to decline.

Open economy with symmetric countries Suppose that in addition to the biased technological growth, trade costs decline at the same rate in all sectors, $d\ln d_{21}^j = d\ln d_{12}^j < 0$ for sector j, and the two countries are symmetric. Due to the symmetry, sectoral trade is balanced: $NX_1^j = 0$ holds for all j, so that the trade effect in (21) does not show up. However, falling trade costs do have an effect in a way that amplifies the expenditure effect by reducing the sectoral price indices further.

Open economy with asymmetric countries Suppose that the two countries are symmetric except that the manufacturing productivity in country 1 is higher than in 2, $A_1^m > A_2^m$. Then

[7] Letting labor as the numeraire, the sectoral price index becomes $P_1^j = w_1/A_1^j = 1/A_1^j$ under autarky.

[8] The sign of the income effect is determined by the sign of the term $\epsilon^j - \sum_{h=a,m,s} \omega_1^h \epsilon^h$. This term is $\omega_1^m(\epsilon^a - \epsilon^m) + \omega_1^s(\epsilon^a - \epsilon^s) < 0$ for agriculture; $\omega_1^a(\epsilon^s - \epsilon^a) + \omega_1^m(\epsilon^s - \epsilon^m) > 0$ for service; $\omega_1^a(\epsilon^m - \epsilon^a) + \omega_1^s(\epsilon^m - \epsilon^s) \gtreqless 0$ for manufacturing. Along with growing per-capita income, the manufacturing value-added share may show a hump shape.

[9] To see this formally, we set $d\ln A_1^a = d\ln A_1^s = 1$, $d\ln A_1^m = \Delta > 1$ and choose labor as the numeraire, $w_1 = 1$. The Baumol effect reduces to $(1-\sigma)(\omega_1^a + \omega_1^s)(1-\Delta) < 0$ in manufacturing and to $(1-\sigma)\omega_1^m \Delta > 0$ in agriculture and service. If we instead set $d\ln A_1^a = \Delta^a < d\ln A_1^m = \Delta^m < d\ln A_1^s = \Delta^s$, the sign of the Baumol effect is determined by that of $d\ln P_1^j - \sum_h \omega_{h=a,m,s} d\ln P_1^h$: $-[(\Delta^a - \Delta^m)(1-\omega_1^a) + (\Delta^m - \Delta^s)\omega_1^s] < 0$ for agriculture; $(\Delta^m - \Delta^s)(1-\omega_1^s) + (\Delta^a - \Delta^m)\omega_1^a > 0$ for service; $(\Delta^a - \Delta^m)(1-\omega_1^m) - (\Delta^a - \Delta^s)\omega_1^s \gtreqless 0$ for manufacturing. The Baumol effect may also lead to a hump-shaped manufacturing value-added share in the course of technological progress.

country 1 is likely to be the net exporter of manufacturing, $NX_1^m > 0$, and the trade effect for its manufacturing tends to be positive. To illustrate this point, we calculate the ratio of country 1's gross exports to its gross imports in manufacturing at free trade ($d_{21}^j = d_{12}^j = 1$) as

$$\begin{aligned}\frac{\pi_{21}^m P_2^m C_2^m}{\pi_{12}^m P_1^m C_1^m} &= \left(\frac{w_2/A_2^m}{w_1/A_1^m}\right)^{\theta^m} \left(\frac{P_2^m}{P_1^m}\right)^{1-\sigma} \left(\frac{w_2 L_2}{w_1 L_1}\right)^{\sigma} \left(\frac{C_2}{C_1}\right)^{\epsilon^m(1-\sigma)} \\ &= \left(\frac{A_1^m}{A_2^m}\right)^{\theta^m} \left(\frac{w_2}{w_1}\right)^{\theta^m+\sigma} \left(\frac{C_2}{C_1}\right)^{\epsilon^m(1-\sigma)},\end{aligned}$$

noting that the trade share is symmetric, $\pi_{11}^m = \pi_{21}^m = 1 - \pi_{22}^m = 1 - \pi_{12}^m$, and the two countries are of equal size, $L_1 = L_2$.[10] If this ratio is greater than unity, country 1 is the manufacturing net exporter, $NX_1^m > 0$. This is more likely if country 1 has a better manufacturing technology (high A_1^m/A_2^m) and country 2 has a greater purchasing power (high w_2/w_1 and C_2/C_1). For the aggregate trade to be balanced, country 1 must be the net importer of agriculture ($NX_1^a < 0$), service ($NX_1^s < 0$) or both. Manufacturing net exports and agricultural/service net imports contribute to an increase in the manufacturing value-added share.[11]

To summarize the role of trade in shaping manufacturing value-added share in advanced countries, trade reinforces the declining trend due to the structural-change forces working under autarky (i.e., the expenditure effect). However, if countries have a comparative advantage in manufacturing (high A_1^m/A_1^j relative to other countries), trade works against the structural-change forces and helps them maintain manufacturing.

3.1.2 Two-country case with capital accumulation and input-output linkages

We then introduce capital accumulation into the two-country model. The sector j's gross value-added share (i.e., sectoral GDP share) in country 1, gdp_1^j, is

$$gdp_1^j = \frac{GDP_1^j}{GDP_1} = \underbrace{\frac{P_1^j C_1^j}{GDP_1}}_{\text{Expenditure}} + \underbrace{\frac{P_1^j M_1^{K,j}}{GDP_1}}_{\text{Investment}} + \underbrace{\frac{NX_1^j}{GDP_1}}_{\text{Trade}},$$

noting that the gross value-added here includes capital depreciation and conceptually differs from the (net) value-added we discussed before, $GDP_1^j \neq VA_1^j$; $GDP_1 = \sum_{j=a,m,s} GDP_1^j = w_1 L_1 + r_1 K_1$ is the aggregate GDP; and $P_1^j M_1^{K,j} = g_1^j P_1^K I_1$ is the expenditure on intermediate

[10] In the two-country case, the sectoral price index in country n is

$$P_n^j = \left(\frac{w_n}{A_n^j}\right)^{\pi_{nn}^j} \left(\frac{d_{ni}^j w_i}{A_i^j}\right)^{\pi_{ni}^j} \left[(\pi_{nn}^j)^{\pi_{nn}^j} (\pi_{ni}^j)^{\pi_{ni}^j}\right]^{-\frac{1}{\theta^j}} e^{\frac{1}{\theta^j}}.$$

[11] The trade effect for manufacturing is given in (21). The biased-technological growth in manufacturing ($d\ln(A_1^m/A_1^j) > 0$) results in $d\ln NX_1^m > 0$, $d\ln NX_1^a < 0$, and $d\ln NX_1^s < 0$, making the trade effect positive more likely.

goods for production of investment good (see (14)). As in the previous case, we derive its logarithmic change as

$$d\ln gdp_1^j = \underbrace{\frac{P_1^j C_1^j}{GDP_1^j} d\ln\left(\frac{P_1^j C_1^j}{GDP_1}\right)}_{\text{Expenditure effect}} + \underbrace{\frac{P_1^j M_1^{K,j}}{GDP_1^j} d\ln\left(\frac{P_1^j M_1^{K,j}}{GDP_1}\right)}_{\text{Investment effect}} + \underbrace{\frac{NX_1^j}{GDP_1^j} d\ln\left(\frac{NX_1^j}{GDP_1}\right)}_{\text{Trade effect}}.$$

The expenditure effect and the trade effect have similar expressions to those in the two-country model without investment given in (21). The investment effect can be further decomposed into

$$\underbrace{\frac{P_1^j M_1^{K,j}}{GDP_1^j} d\ln\left(\frac{P_1^j M_1^{K,j}}{GDP_1}\right)}_{\text{Investment effect}} = \frac{g_1^{K,j} P_1^K I_1}{GDP_1^j}\left[(1-\sigma^K)\left(d\ln P_n^j - \sum_{h=a,m,s} g_1^{K,h} d\ln P_n^h\right) - d\ln E_n\right],$$

noting that $g_1^{K,j} = P_1^j M_1^{K,j} / \sum_{h=a,m,s} P_1^h M_1^{K,h}$ is the cost share of sector-j goods for production of investment good and $E_n = \sum_{h=a,m,s} P_n^h C_n^h$ is the total consumption expenditure. Suppose that the elasticity of substitution between sectoral inputs for producing capital goods is $\sigma^K \in (0,1)$. The expression above shows that the investment effect is likely to be negative for manufacturing with growing productivity faster than the other sectors. The mechanism is similar to the Baumol effect operating in the expenditure effect.

3.1.3 General case

With clear intuition of two-country case in hand, it is easy to extend it to our quantifiable model. The sector j's GDP share in country n in time t is

$$gdp_n^j = \underbrace{\sum_{h=a,m,s} \lambda_{n,t}^{j,h} \frac{P_{n,t}^h C_{n,t}^h}{GDP_{n,t}}}_{\text{Consumption Expenditure}} + \underbrace{\sum_{h=a,m,s} \lambda_{n,t}^{j,h} \frac{g_{n,t}^{K,h} P_{n,t}^K I_{n,t}}{GDP_{n,t}}}_{\text{Investment}} + \underbrace{\sum_{h=a,m,s} \lambda_{n,t}^{j,h} \frac{NX_{n,t}^h}{GDP_{n,t}}}_{\text{Net exports}} - \underbrace{\sum_{h=a,m,s} \lambda_{n,t}^{j,h} \frac{\widetilde{T}_{n,t}^h}{GDP_{n,t}}}_{\text{Tariff revenues}},$$

where $GDP_{n,t}$ is the total value-added plus tariff revenues, $GDP_{n,t} = w_{n,t}L_{n,t} + r_{n,t}K_{n,t} + \sum_{h=a,m,s} \widetilde{T}_n^h$. In addition to the consumption expenditure and the net-export terms, two new terms enter, investment and tariff revenues. The investment raises the value-added share, while the tariff revenues reduces it. Since sectors are linked through intermediate-good use, sector j's value-added share is affected not only by the terms of its own sector but also those of the other sectors. The strength of the sectoral linkage is summarized by $\{\lambda_{n,t}^{j,h}\}$, the coefficients of (a sort of) the Leontief inverse matrix. A 1% increase in the sector h's share of final demand either from expenditure, investment, net exports or tariff revenues raises sector j's value-added share by $\lambda^{j,h}$%.

We plan to quantify each contribution to the sectoral value-added share. In the following

Table 1: List of Countries

Australia	Canada	Spain	Greece	Japan	Portugal
Austria	China	Finland	India	Korea	Sweden
Belgium	Germany	France	Ireland	Mexico	Taiwan
Brazil	Denmark	UK	Italy	Netherlands	USA

quantitative exercise, we assume away tariff revenues.

4 Calibration and Solution Algorithm

We bring the model to the data for the global economy. We first describe our main data sources and then discuss the calibration of the structural parameters. We then present the solution algorithm for computing transition paths.

4.1 Data

Our primary data source is the World Input-Output Database (WIOD) Release 2016 and the Long-Run WIOD (Woltjer et al., 2021; Timmer et al., 2015), which allows us to observe the intermediate input uses across different countries and sectors of both origin and destination. By merging the two datasets, we constructed a database that covers half a century, 1965–2014. Our empirical exercise encompasses 24 countries (see Table 1) and the rest of the world (RoW). They are the listed countries in the Long-Run WIOD, and we moved Hong Kong to the RoW. We aggregate the ISIC industries into three categories as in Table 2. We label D15-D16 Food, Beverages, and Tobacco as agriculture instead of manufacturing due to the nature of its products. Construction and utility supply (e.g., electricity, gas, and water supply) is categorized as a service.[12] We complement the WIOD data with the Penn World Table (PWT) 10.0 (Feenstra et al., 2015) and CEPII Gravity database (Mayer and Zignago, 2011).

4.2 Structural Parameters

We begin with discussing our calibration of the parameters in preferences. The discount factor β is set at 0.96 to be consistent with a real interest rate of 4 percent per year. We set the inter-temporal elasticity of substitution $\psi = 2$ following Ravikumar et al. (2019). For parameters in the period utility, we choose the elasticities of substitution across sectors $\sigma = 0.5$, and the degree of nonhomotheticity $\epsilon^a = 0.05$ in agriculture, $\epsilon^m = 1$ in manufacturing, and $\epsilon^s = 1.2$ following Comin et al. (2021). $\sigma < 1$ implies that sectoral goods are compliments,

[12] Whether the construction and utilities are categorized as manufacturing, service, or an independent sector differs across previous studies. For example, Sposi (2019); Sposi et al. (2021), Uy et al. (2013), Smitkova (2023), Lewis et al. (2022) include construction in the service sector, while Święcki (2017), García-Santana et al. (2021), Herrendorf et al. (2014, 2021), and Betts et al. (2017) include it in the manufacturing sector.

Table 2: Three Sectors and Corresponding ISIC3 Codes

Sector	ISIC3	Description
Agriculture	A to B	Agriculture, Hunting, Forestry and Fishing
	C	Mining and Quarrying
	D15 to 16	Food, Beverages and Tobacco
Manufacturing	D17 to 19	Textiles, Textile, Leather and Footwear
	D21 to 22	Pulp, Paper, Printing and Publishing
	D23	Coke, Refined Petroleum and Nuclear Fuel
	D24	Chemicals and Chemical Products
	D25	Rubber and Plastics
	D26	Other Non-Metallic Mineral
	D27 to 28	Basic Metals and Fabricated Metal
	D29	Machinery, Nec
	D30 to 33	Electrical and Optical Equipment
	D34 to 35	Transport Equipment
	D n.e.c.	Manufacturing, Nec; Recycling
Service	E	Electricity, Gas and Water Supply
	F	Construction
	G	Wholesale and Retail Trade
	H	Hotels and Restaurants
	I60 to 63	Transport and Storage
	I64	Post and Telecommunications
	J	Financial Intermediation
	K	Real Estate, Renting and Business Activities
	L to Q	Community Social and Personal Services

and, therefore, the Baumol effect is at work. Values of ϵs suggest that agriculture is a necessity, service is a luxury, and manufacturing goods start as a luxury and then become a necessity as the consumption expenditure rises.

Value-added shares in production function $\gamma_{n,t}^{j}$ is directly observed in the IO table. Capital shares within value-added $\alpha_{n,t}^{j}$ is calibrated as one minus labor shares, which is obtained from the PWT. Since the PWT does not provide the sectoral labor share, we apply the common value across sectors for each year and country. We set the elasticity of substitution across intermediate inputs $\sigma^j = 0.38$ for all j following Atalay (2017). For the capital goods production, we set the elasticity of substitution $\sigma^K = 0.29$ following Sposi et al. (2021). Shape parameters of the Fréchet distribution, i.e., trade elasticities, are chosen as $\theta^a = 8.11$ and $\theta^m = \theta^s = 4.55$. Elasticities for the goods sectors are calibrated based on the estimates of Caliendo and Parro (2015), and we set the elasticity for the service sector to be the same as the manufacturing sector. We will discuss the calibration of productivity and exogenous demand shifters below.

We set the adjustment cost elasticity in the low of motion for capital $\lambda = 0.75$ following Eaton et al. (2016) and the depreciation rate of capital $\delta_{n,t}$ is obtained from the PWT.

4.3 Path of Fundamentals

We calibrate the iceberg trade costs (including tariffs and non-tariff barriers), b^j_{nt}, and average productivity, $A^j_{n,t}$, following Levchenko and Zhang (2016). To begin with, we express the trade share normalized by its own trade share as follows:

$$\frac{\pi^j_{ni,t}}{\pi^j_{nn,t}} = \frac{\left(\frac{\tilde{c}^j_{i,t} b^j_{ni,t}}{A^j_{i,t}}\right)^{-\theta^j}}{\left(\frac{\tilde{c}^j_{n,t}}{A^j_{n,t}}\right)^{-\theta^j}} = \left(\tilde{c}^j_{i,t}/A^j_{i,t}\right)^{-\theta^j} \times \left(\tilde{c}^j_{n,t}/A^j_{n,t}\right)^{\theta^j} \times \left(b^j_{ni,t}\right)^{-\theta^j}.$$

Taking the log of both sides gives:

$$\ln\left(\frac{\pi^j_{ni,t}}{\pi^j_{nn,t}}\right) = \ln\left(\tilde{c}^j_{i,t}/A^j_{i,t}\right)^{-\theta^j} + \ln\left(\tilde{c}^j_{n,t}/A^j_{n,t}\right)^{\theta^j} - \theta^j \ln\left(b^j_{ni,t}\right).$$

We then express the log of the iceberg trade cost using the set of bilateral observables as:

$$\ln\left(b^j_{ni,t}\right) = \text{dist}^j_{k(ni)} + \text{CB}^j_{ni,t} + \text{CU}^j_{ni,t} + \text{RTA}^j_{ni,t} + ex^j_{i,t} + \nu^j_{ni,t},$$

where $\text{dist}^j_{k(ni),t}$ is the contribution to trade costs of the distance between n and i being in a certain interval[13], $\text{CB}^j_{ni,t}$ is the indicator if the two countries n and i share the border, $\text{CU}^j_{ni,t}$ indicates if they are in the currency union, $\text{RTA}^j_{ni,t}$ indicates if they are in a regional trade agreement (WTO definition), ex^j_{it} is the exporter fixed effects, and $\nu^j_{ni,t}$ is the bilateral error term. Note that each component in the bilateral trade cost is indexed by t and we estimate them as the fixed effects interacted with years. This implies that, for instance, the contribution of distance to trade costs can vary over time due to the technological progress of transportation (e.g., reduction in container shipping costs). Exporter fixed effects are included to allow asymmetry in trade costs in the spirits of Waugh (2010). We plug this into the trade share equation (15) and estimate the following using the Pseudo Poisson Maximum Likelihood

[13]We follow Eaton and Kortum (2002) and intervals are defined, in miles, $[0, 350]$, $[350, 750]$, $[750, 1500]$, $[1500, 3000]$, $[3000, 6000]$, $[6000, \max]$

(PPML) for each sector j while pooling all sampled countries and years:

$$\ln\left(\frac{\pi^j_{ni,t}}{\pi^j_{nn,t}}\right) = \underbrace{\left(\ln\left(\tilde{c}^j_{i,t}/A^j_{i,t}\right)^{-\theta^j} - \theta^j ex^j_{it}\right)}_{\text{exporter-year F.E.}} + \underbrace{\ln\left(\tilde{c}^j_{n,t}/A^j_{n,t}\right)^{\theta^j}}_{\text{importer-year F.F.}}$$
$$\underbrace{-\theta^j\left(\text{dist}^j_{k(ni),t} + \text{CB}^j_{ni,t} + \text{CU}^j_{ni,t} + \text{RTA}^j_{ni,t}\right)}_{\text{Bilateral observables}} - \theta^j \nu^j_{ni,t}.$$

Estimating the gravity equation above allows us to identify the technology-cum-unit-cost term, $\ln\left(\tilde{c}^j_{n,t}/A^j_{i,t}\right)^{\theta^j}$, for each county and year as an importer-year fixed effect, relative to the reference country and year (US in 1965), which we denote by $S^j_{nt} = \left(\tilde{c}^j_{n,t}/A^j_{n,t}\right)^{\theta^j} / \left(\tilde{c}^j_{US,1965}/A^j_{US,1965}\right)^{\theta^j}$. We can then tease out the term $(-\theta^j ex^j_{it})$ from the exporter-year fixed effects. By combining all the terms in the bilateral trade costs, we can recover the asymmetric bilateral trade costs.

To back out productivity, we need a few preliminary steps. First, following Shikher (2013), we recover the sectoral price indices as follows. We define the own trade share relative to the ones of the reference country and year:

$$\frac{\pi^j_{nn,t}}{\pi^j_{US,US,1965}} = \frac{\left(\tilde{c}^j_{n,t}/A^j_{n,t}\right)^{-\theta^j}}{\left(\tilde{c}^j_{US,1965}/A^j_{US,1965}\right)^{-\theta^j}} \left(\frac{P^j_{n,t}}{P^j_{US,1965}}\right)^{\theta^j} = \frac{1}{S^j_{nt}} \left(\frac{P^j_{n,t}}{P^j_{US,1965}}\right)^{\theta^j}.$$

Hence, for given trade elasticity θ^j we have,[14]

$$\frac{P^j_{n,t}}{P^j_{US,1965}} = \left(\frac{\pi^j_{nn,t}}{\pi^j_{US,US,1965}} S^j_{nt}\right)^{1/\theta^j}.$$

Being armed with the sectoral price indices, we next back out the exogenous demand shifters for intermediate inputs, $\kappa^{jh}_{n,t}$, by solving the system of equations for each j, n, and t:

$$g^{j,h}_{n,t} = \frac{\kappa^{j,h}_{n,t}(P^h_{n,t})^{1-\sigma^j}}{\sum_{h'=a,m,s} \kappa^{j,h'}_{n,t}(P^{h'}_{n,t})^{1-\sigma^j}}.$$

by restricting $\sum_{h'} \kappa^{j,h'}_{n,t} = 1$ for each j, n, and t. The left-hand side of the equation, $g^{j,h}_{n,t}$, is the share of expenditure spent on input from sector h in total input costs of j, which is directly observed in the IO table. After obtaining $\kappa^{jh}_{n,t}$, we can recover the CES price index for the composite intermediate good $\xi^j_{n,t}$ according to (12). We analogously back out the exogenous demand shifter in the capital goods production function, $\kappa^{Kh}_{n,t}$, by solving the system

[14] Note that the price indices are recovered relative to the US in 1965 for each sector. That means the US price index is 1 for all sectors in 1965.

of equations for each n and t:

$$g_{n,t}^{K,h} = \frac{\kappa_{n,t}^{K,h} (P_{n,t}^{h})^{1-\sigma^K}}{\sum_{h'=a,m,s} \kappa_{n,t}^{K,h'} (P_{n,t}^{h'})^{1-\sigma^K}}.$$

by restricting $\sum_{h'} \kappa_{n,t}^{K,h'} = 1$.

Having $\xi_{n,t}^{j}$ in hand, we can compute the cost of the input bundle according to (11). To recover wages, we compute the wage bill of each economy by multiplying the labor share obtained from the PWT and the economy-wide value-added computed based on the WIOD. We then divide the wage bill by the total employment of the country sourced from the PWT. For the rental price of capital, we divide the return to capital (i.e., total value-added minus the wage bill) by the capital stock. We compute the economy-wide capital stock sequentially over time according to (8), where we obtain the initial period capital stock from the PWT and the investment (gross fixed capital formation) from the WIOD. Then, we can recover the productivity $A_{n,t}^{j}$ by:[15]

$$\frac{A_{n,t}^{j}}{A_{US,1965}^{j}} = (S_{n,t}^{j})^{1/\theta^j} \left(\frac{\tilde{c}_{n,t}^{j}}{-\tilde{c}_{US,1965}^{j}} \right).$$

Using the sectoral price indices computed above, we calibrated the sectoral demand shifter $\Omega_{n,t}^{j}$ as follows. First, we guess the vector of $\{\Omega_{n,t}^{j}\}$. Given the data on consumption expenditure $E_{n,t}$ from the WIOD, population $L_{n,t}$ from the PWT, prices $P_{n,t}^{j}$ and guessed values of $\Omega_{n,t}^{j}$, solve the consumption index $C_{n,t}^{j}$ according to (4). Using the computed consumption index, we can find the unique vector of $\Omega_{n,t}^{j}$ (up to normalization for each n and t) by applying the Perron-Frobenius theorem to (5). We then use the value of $\Omega_{n,t}^{j}$ as the new guess and repeat the steps until we find the fixed points.

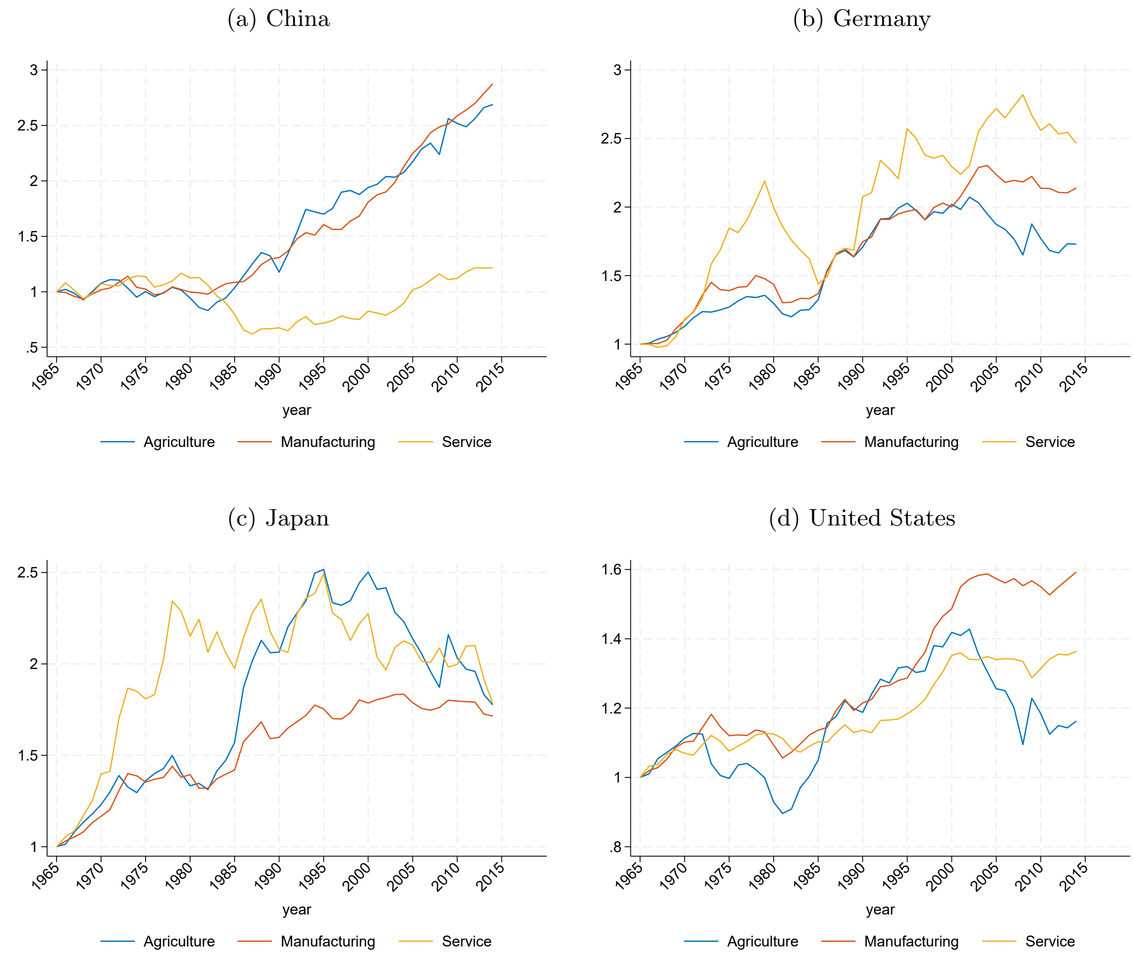
The intertemporal demand shifter $\zeta_{n,t}$ is backed out sequentially according to (9). Using the consumption index $C_{n,t}$ obtained above, we can construct the series of $\zeta_{n,t}$ for each country with normalizing the one of the last sample year $\zeta_{n,2014}$ to be unity.

4.4 Values of Fundamentals

Before moving on to the quantitative results, we summarize the baseline fundamentals we calibrated above. Figure 2 shows the evolution of sectoral productivity in four countries, China, Germany, Japan, and the US. We normalize the productivity in 1965 to be 1 and take the moving average over 3 years to remove the noise. In Germany, Japan, and the US, the productivity of manufacturing increased more than that of the service sector over the period. For example, the manufacturing productivity in the US increased by a factor of 1.8 while the service sector productivity increased by a factor of 1.3. The higher productivity growth

[15] By construction, sectoral productivity takes 1 for the US in 1965 in all sectors.

Figure 2: Productivity Evolution (1965=1)



in manufacturing than services implies that the expenditure share on manufacturing may drop due to the Baumol effect, even if we do not take into account impacts of international trade and non-homotheticity preferences-driven demand changes. In China, the service sector productivity grew more, by a factor of 5.5, than manufacturing productivity, by a factor of 4.5. Despite the relatively lower growth in the manufacturing productivity to the service sector, the manufacturing growth is much higher in level than those in Germany, Japan and the US.

Figure 4 summarizes the evolution of trade costs in the four countries. For each country and year, we compute the simple arithmetic average of the bilateral trade costs with all its trading partners. Again, we normalize the values in 1965 to be 1 and take moving averages over 3 years. Over the five decades, China and the US observed a sharp drop in service trade costs, almost 70% in China and 90% in the US. However, the major drop in the service trade costs in the two countries happened between 1969 and 1970 of the sample period, and it has

Figure 3: Productivity Evolution

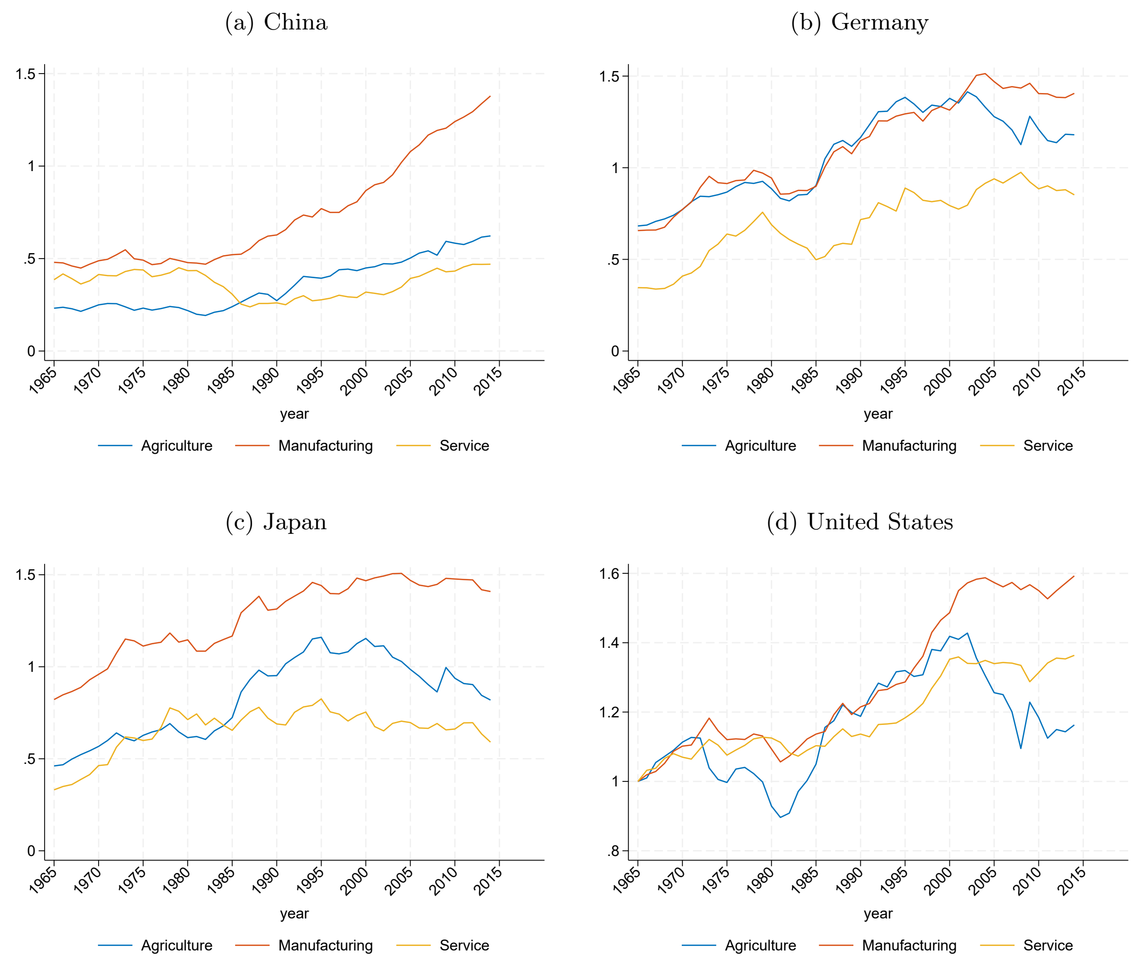
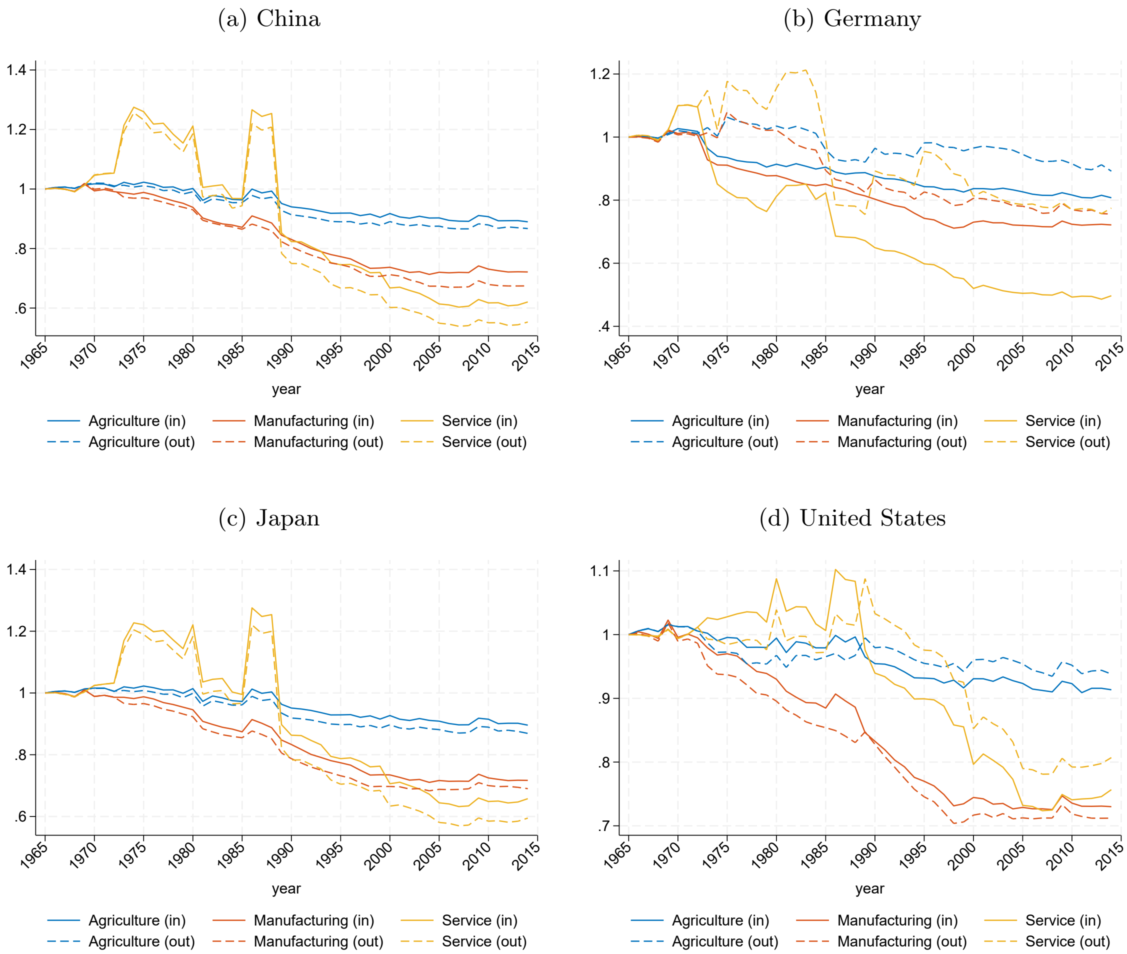


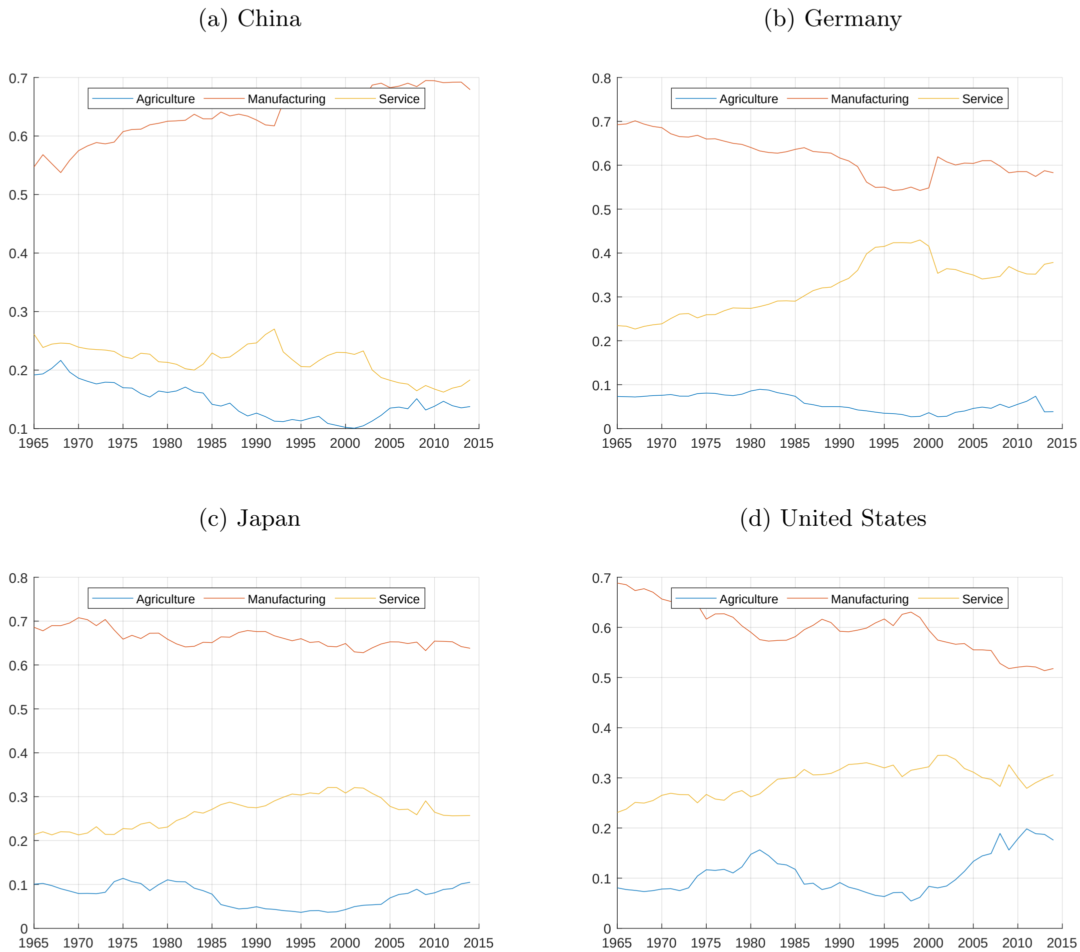
Figure 4: Evolution of Average Trade Costs (Inward and Outward)



been more stable since then. After 1970, service trade costs have dropped only by 20% in China and 25% in the US, which is lower than the decline in manufacturing trade costs over the entire sampled period (30% in China and 65% in the US). Germany and Japan also show a large decline in manufacturing trade costs, by 40% and 30%, respectively.

Figure 5 and 6, respectively, demonstrate the intermediate input cost shares for the manufacturing sector and for the capital good production, which are used for the calibration of $\kappa_{n,t}^{h,j}$ and $\kappa_{n,t}^{K,j}$. Except for China, in all three countries, service inputs are becoming more important in manufacturing production. As we saw above, since the productivity of manufacturing grows faster than service sector and the elasticity of substitution across inputs is less than one, the Baumol effect may be a determinant of the increasing share of of service. Growing share of service is also observed for the capital good production in some countries. In addition to the Baumol effect, the nonhomotheticity in the production function may be

Figure 5: Cost Shares in Manufacturing Production



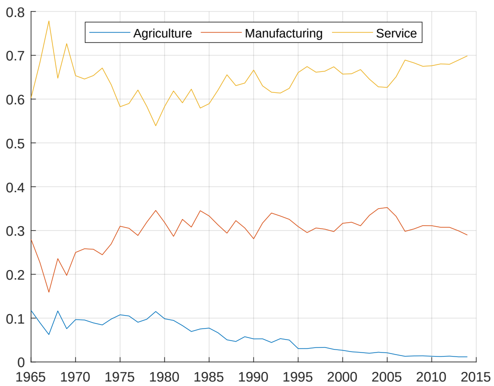
another reason for the rising share of service. This is beyond the scope of this paper but is an interesting topic for future research.

4.5 Solution Algorithm

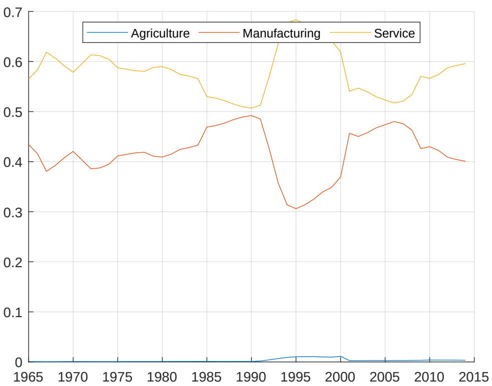
We solve the equilibrium transition path backward. We first solve the model for the steady state according to Definition 2, assuming the 2014 fundamentals (e.g., productivity, trade costs, exogenous demand shifters, etc) last forever. We then suppose that the economy will reach the steady state in 2464 (in 450 years). The solution algorithm for the transition path has two loops: the outer loop finds the sequence of investment (saving) rate $\{\rho_{n,t}\}_{n,t}$ that satisfies the dynamic optimality condition governed by the Euler equation (9) and the inner loop solves the intra-temporal optimization for each period (i.e., solving the sectoral prices and factor prices that satisfy the equilibrium conditions listed in Definition 1). More specifically, For the given

Figure 6: Cost Shares in Capital Good Production

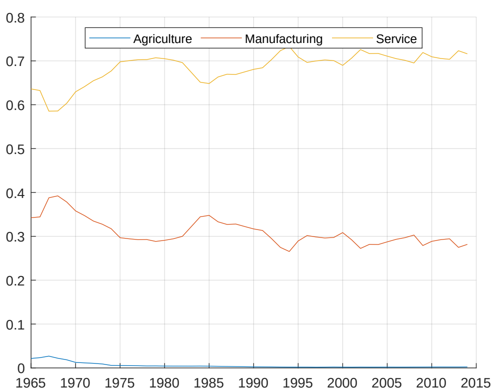
(a) China



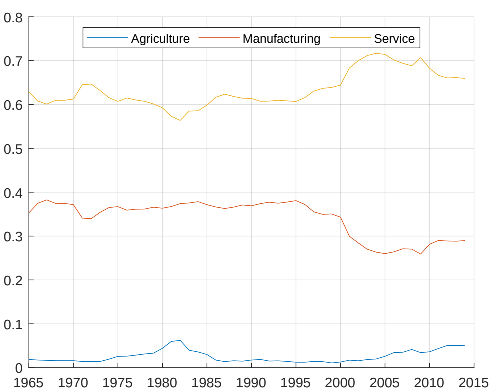
(b) Germany



(c) Japan



(d) United States



sequence of $\{\rho_{n,t}\}_{n,t}$ and the initial period capital stock, we first solve the static equilibrium period-by-period sequentially from 1965 to 2464. After we solve the periodic equilibria up to the year 2464, we update $\rho_{n,t}$ backward from 2464 to 1965 according to the Euler equation. Refer to Ravikumar et al. (2019) for the details of the outer loop iteration.

5 Quantitative Results

This section presents the quantitative results of the calibrated model.

5.1 Fit of the Baseline Model

We first show the baseline results. To examine the model's ability to match the data, Figure 7 compares the model-implied (solid lines) value-added shares in three sectors (yellow for agriculture, orange for manufacturing, and blue for services) with the data counterparts (dashed lines) for three advanced economies, Germany, Japan, and the US. In the three countries, the model captures the overall trend of falling manufacturing and rising services over time. In Japan, the model over-(under-)predicts the agriculture (manufacturing) value-added share, while in the US, the model over-(under-)predicts the manufacturing (services).

Next, we show the expenditure shares in final consumption $\omega_{n,t}^{j}$ implied by the model and the data (Figure 8). In all of the three countries presented, the model accounts for the shift of expenditure from agriculture and manufacturing to service over time. To understand the underlying mechanism of declining manufacturing expenditure shares (rising service shares), Figure 9 shows the change in sectoral prices over time, where we normalize the prices in the initial period to be one. We see that, in all of the three countries, the manufacturing price drops more than the other two sectors. Due to the complementarity in consumer preferences (i.e., $\sigma < 1$), falling manufacturing prices increase the service expenditure share due to the Baumol effect. Furthermore, nonhomothetic preferences favor rising service expenditures as national income grows over time.

Finally, Figure 9 compares the saving rates in the baseline equilibrium to the data. In all three countries, the model predicts a higher saving rate than the data counterpart in earlier years. The model-implied saving rate gradually falls and converges to the levels close to the data.

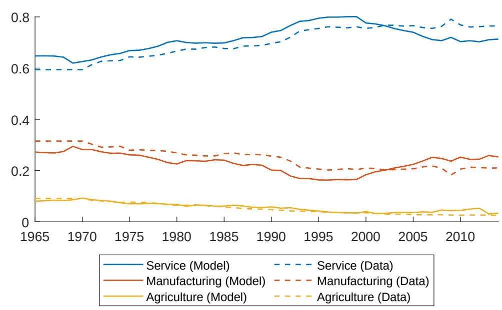
5.2 Counterfactuals

Now, we will use the model to understand the international and intranational driving forces of structural change. Specifically, we consider the following three counterfactual scenarios.

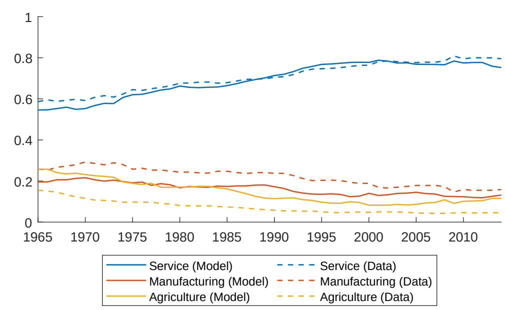
1. The trade costs between all country pairs are held fixed at the 1965 level forever (1965 trade costs).

Figure 7: Model Fit: Sectoral Value Added Share in GDP

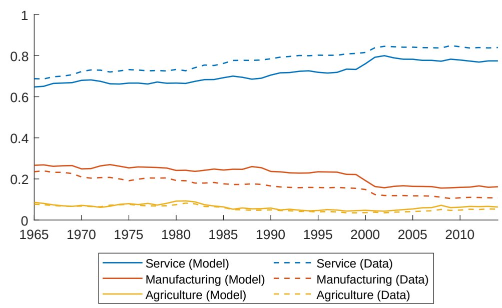
(a) Germany



(b) Japan



(c) US



2. The productivity in all countries are held fixed at the 1965 level forever (1965 productivity).

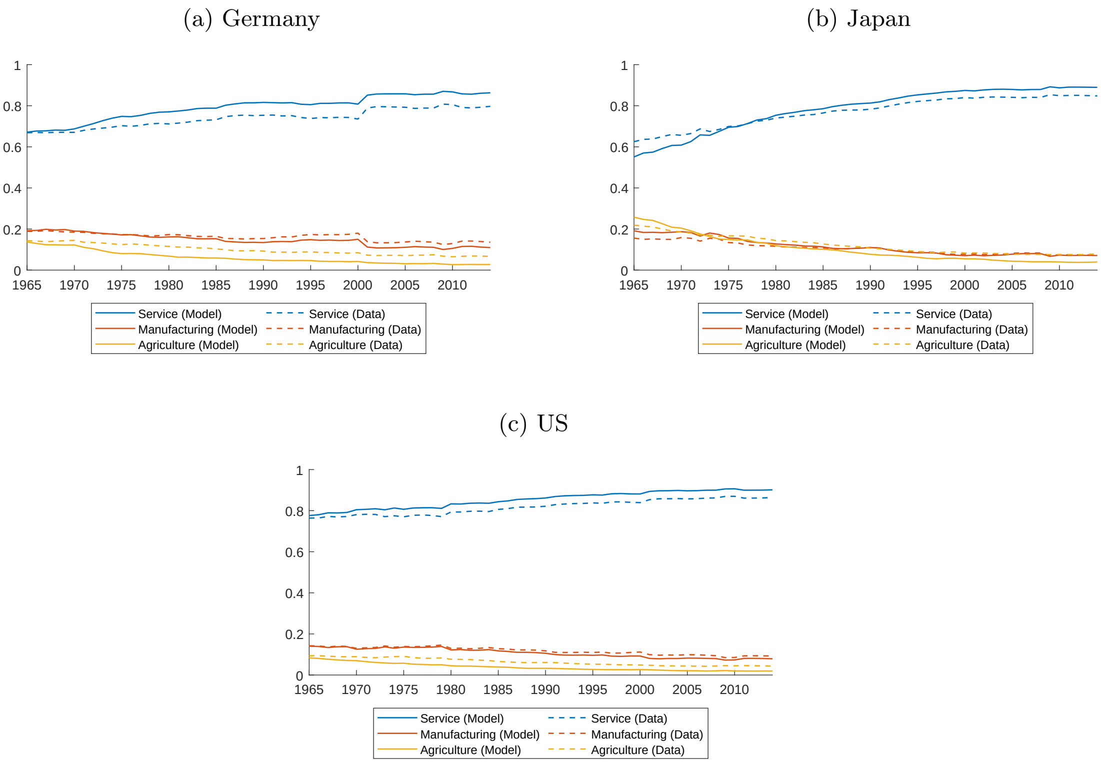
3. China's productivity and trade costs with all other countries are held fixed at the 2000 level from 2000 onwards (no China shock).

The first one traces how the changes in trade costs since 1965 contributed to the changes in sectoral composition. The second teases out the contribution of the change in productivity since 1965. The last one illustrates how China's productivity improvement and the decline in trade costs between China and other countries impacted the industry structure in advanced economies.

Figure 11 lays out the shares of manufacturing in value-added in the baseline and three counterfactual equilibria for three countries: Germany, Japan, and the US. Solid lines are for the baseline, dashed lines for the first counterfactual with the 1965 trade costs, dotted lines for the second counterfactual with the 1965 productivity, and red lines for the third counterfactual without the China shock.

Before taking a closer look at the results for each country, we will summarize main findings. First, our results suggest that international trade has heterogeneous impacts on sectoral

Figure 8: Model Fit: Sectoral Expenditure Share in Final Consumption



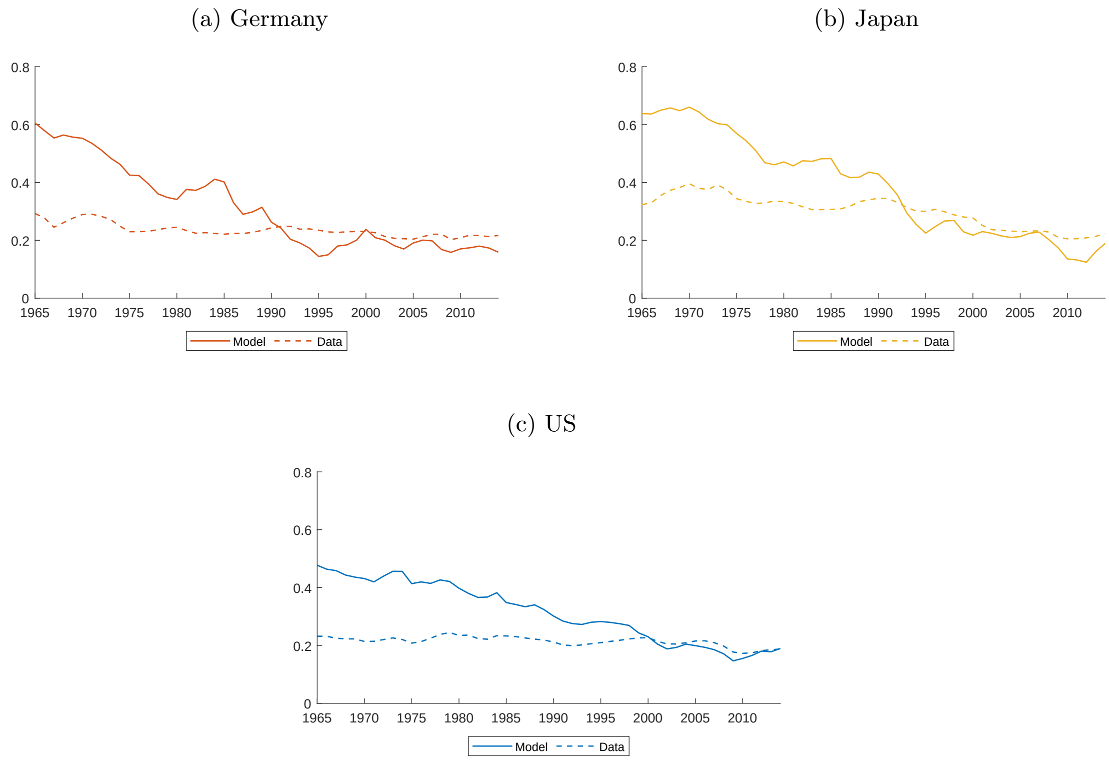
composition across countries. Specifically, we find that globalization (i.e., declining trade costs) expanded the manufacturing of the US and Germany while it shrank Japanese manufacturing. Second, in line with the first point, the China shock has heterogeneous impacts across countries. Most strikingly, in the US, the result suggests that the fall in US manufacturing after 2000 can be entirely attributed to the China shocks.

Let's look at the results for each of the three countries. The top panel, (a), exhibits the manufacturing shares in value-added in Germany. From 1965 to 2000, the baseline and three counterfactuals yield similar value-added shares of manufacturing. Since 2000, however, they diverge. Keeping the productivity or trade costs as in 1965 yields lower manufacturing shares than the baseline. The decline in trade costs since 2000 expanded the relative size of manufacturing in Germany, as Germany has a comparative advantage in manufacturing.[16] In contrast, the "no China shock" scenario yields higher manufacturing value-added shares than the baseline equilibrium. Therefore, the rise in China's productivity and China's integration into the global economy shrank the relative size of manufacturing in Germany.[17]

[16] Along with Japan, Sweden, the US, Eaton and Kortum (2002) call Germany as a natural manufacturer.

[17] On the other hand, Dauth et al. (2014) found that China's trade integration retained the manufacturing in Germany. The difference between their result and ours may be partly due to the general equilibrium effect of

Figure 9: Model Fit: Saving Rate



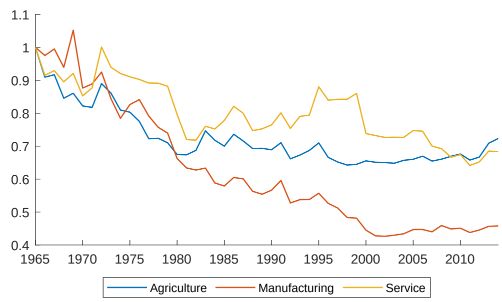
The second panel, (b), plots the manufacturing shares in value-added in Japan. Keeping the trade costs at the 1965 level yields higher manufacturing shares than the baseline. Trade cost reductions would contribute to the growth of manufacturing exports. On the other hand, they would lead to lower-priced imports and push a greater downward pressure on the manufacturing price than the other sectors' prices since manufacturing production relies more on tradable manufacturing inputs. The latter effect dominates the former one so that trade cost reduction from the 1965 level to the current one results in a greater manufacturing share. Keeping the productivity at the 1965 level yields lower manufacturing shares than the baseline. The "no China shock" scenario yields lower manufacturing shares than the baseline until 2014, and they converged. That is, in a medium term, the China shock increased the relative size of manufacturing in Japan. This is consistent with Taniguchi's (2019) empirical finding that import penetration by Chinese products allows the Japanese manufacturers to source lower-priced intermediates and thus to increase manufacturing employment across Japanese prefectures.

The last panel, (c), shows the manufacturing shares in value-added in the United States. The

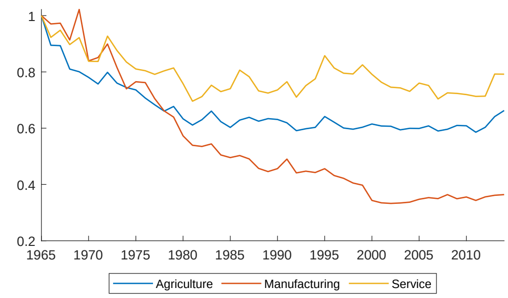
the world trade market.

Figure 10: Transition of Sectoral Prices under Baseline Equilibrium (1965=1)

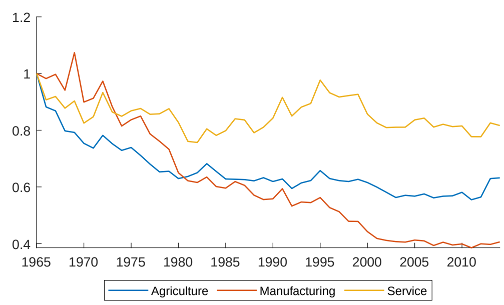
(a) Germany



(b) Japan



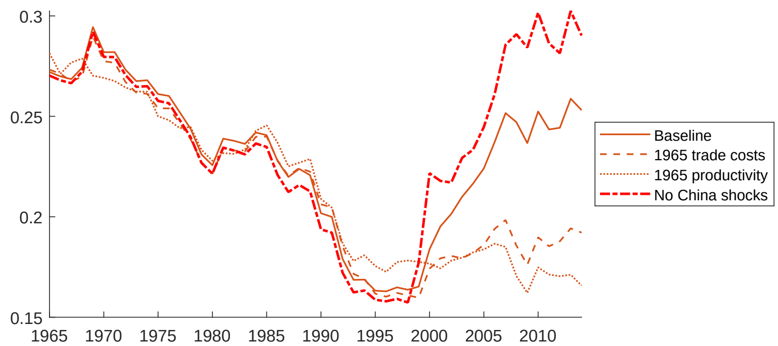
(c) US



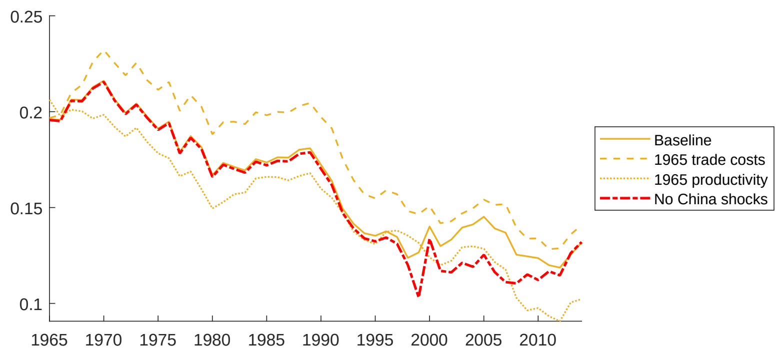
baseline, 1965 trade costs, and 1965 productivity equilibria all exhibit similar manufacturing shares. However, the gap from the baseline is greater in the equilibrium with the constant 1965 productivity. Productivity growth from the 1965 level to the current one results in a greater manufacturing share. This can be partly explained by the fact that relative productivity in manufacturing to the other sectors is particularly high in 1965 and the subsequent growth narrows the productivity difference. What is striking is the effect of the China shock. The "no China shock" scenario yields largely constant manufacturing shares. Therefore, virtually all of the decline in the manufacturing share since 2000 is attributable to the China shocks.

Figure 11: Counterfactual Manufacturing Shares in Value-Added

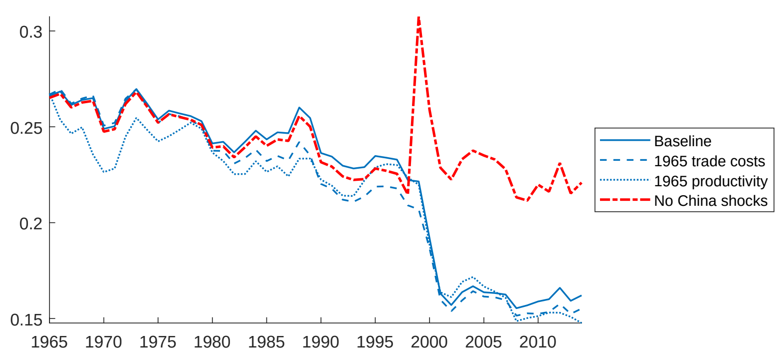
(a) Germany



(b) Japan



(c) US



6 Conclusion

We developed a dynamic general equilibrium model that features international trade, capital accumulation, sector-biased productivity growth, and non-homothetic preferences to dissect the evolution of sectoral composition in the global economy. We brought the model to the data for the world economy with 24 countries over the period of 1965–2014. Our calibrated model captured the declining share of manufacturing and rising share of service in value-added in the US. We undertook a few counterfactual experiments to explore the role of the evolution of productivity and trade costs since 1965 and the China shock. In Germany and the US, the China shock reduced the manufacturing share in value-added. Especially in the US, the China shock fully explained the decline in the manufacturing share since 2000. In contrast, in Japan, the China shock increased the manufacturing share.

A few more next steps are in order. We plan to provide a more detailed decomposition of the effect of falling trade costs on sectoral composition according to the analytical formulas developed in Section 3. Our expected results answer questions such as: to what extent globalization would reduce manufacturing if non-homothetic preferences and sector-biased productivity growth were not in operation; whether the decline in manufacturing resulting from globalization has similar welfare implications to the one resulting from sector-biased productivity growth. Furthermore, we plan to apply our framework to study a few globalization episodes mentioned in the Introduction, in particular, the impact of the eastward enlargement of the EU in 2004 and 2007 on sectoral composition and trade patterns among the EU member states.

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