Structural Change and Global Trade

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Abstract

Over time, countries consume a larger share of their income in the services or less-traded sector. This pattern of structural change is one of the most salient features of economic development. As the world economy becomes more services oriented, it will become "less open" in terms of total trade over expenditure. Thus structural change impacts long-run global trade. This paper quantitatively studies the impact of structural change on global trade, and we find that world trade as a fraction of world expenditure would have been about 23 percentage points higher if structural change had not occurred. We find little evidence that this drag on trade growth has become more pronounced in recent years.

JEL classifications: F41, L16, O41

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1 Introduction

Long-run economic growth is accompanied by seismic shifts in the types of goods and services countries buy and produce—countries move away from the consumption of goods towards services. Such structural change is thoroughly studied and is well-known to be a foundational component of economic growth. Indeed, from the period 1970 to 2015, the share of services in total world expenditure rose from 53 percent to 80 percent.[1] At the same time, services are far less traded than goods with total trade in services only about 14 percent of total service expenditure in 2015, compared to goods, where the total (gross) value of trade is nearly 200 percent of total expenditure. Taking these two trends together means that as a greater share of the world economy is devoted to services, the share of spending on less-tradable consumption categories will increase relative to more-tradable goods. Thus structural change could have profound implications on global trade.

There is a robust literature that has focused on the impact of global trade on structural change. The impact of structural change on global trade, by contrast, remains largely unexplored. The goal of this paper is to quantify the effect of structural change on international trade flows. We start with a straightforward but naïve computation of counterfactual global trade that had no structural change; in other words, assuming that sectoral expenditure shares are fixed at the initial year of data, while the sectoral trade over expenditure ratios rise as in the data. We find that the global trade to expenditure ratio in 2015 would have been 94 percent or 45 percentage points higher than the 48 percent in the data. Indeed, structural change may be more consequential for international trade than international trade is for explaining the pattern of structural change in many countries.

This simple calculation suggests that the world movement towards the consumption of less-tradables might suppress the growth of trade flows in the last five decades. At the same time, the exercise leaves something to be desired. Not only is the endogenously changing pattern of consumption in these countries potentially an important factor in driving what countries trade through its impact on factor prices, but there are many other factors, such as sectoral input-output linkages and trade costs, that could simultaneously affect both sectoral expenditure and trade shares. The interactions between these factors imply that a true quantification of the effects of structural change on trade patterns needs a more fully fleshed out system.

For this reason, we build a tractable general equilibrium model that allows for endogenous structural change and trade patterns, similar to Uy, Yi and Zhang (2013) and Sposi (2016). The set of non-homothetic preferences we use feature non-unitary income and substitution elasticities to allow dynamics of income and relative prices to shape sectoral expenditure shares.[2] On the production side, trade flows are governed by Ricardian forces as in Eaton and Kortum (2002), and

[1] Throughout this paper, we will refer to trade as a fraction of expenditure. Global expenditure of goods and services is equal to global GDP of goods and services because global trade is balanced and all sectoral linkages are included. On a country level or by sector, however, final expenditure need not equal value-added.

[2] We use the preferences of Comin, Lashkari and Mestieri (2015).

it features intermediate input linkages as in Levchenko and Zhang (2016). Sectoral productivities and bilateral trade costs at the sector level vary over time and influence the patterns of production and trade.

We set up the exercise as a N-country model, with each country having its own ongoing processes of structural change, and we calibrate the underlying deep parameters and time-varying processes of the model similar to Sposi (2016). We conduct a similar counterfactual as the one specified in the empirical section by setting the preferences to be logarithm across sectors, which effectively shuts down structural change by delivering constant expenditure shares for all sectors and all countries across time. What is different from the simpler empirical calculation is that the model allows for counterfactual structural change to flow through an input-output structure and also affect endogenous factor prices. We show that the model-based counterfactual still implies a substantial increase in the global trade-to-expenditure ratio, but that it is somewhat less than the simple empirical counterfactual. The primary source of this reduced counterfactual is that goods openness in the counterfactual is somewhat lower: goods expenditure rises relative to the baseline, but through the input-output structure of the model, goods trade does not rise by the same degree.

A well-established literature documents how international trade and openness affects structural change. Matsuyama (2009) emphasized that trade can alter patterns of structural change and that using closed-economy models may be insufficient. Uy et al. (2013) find that non-homothetic preferences in an open economy can explain South Korea's hump-shaped manufacturing employment share over time. Betts, Giri and Verma (2016) explore the effects of South Korea's trade policies on structural change, finding that these policies raised the industrial employment share and hastened industrialization in general. Teignier (2016) finds that international trade in agricultural goods affected structural change in the United Kingdom even more than South Korea. Sposi (2016) documents how the input-output structure of advanced economics is systematically different from those of developing economies, and that this contributes to industry's hump-shaped response of the industry employment share over time. McMillan and Rodrik (2011) find that the effect of structural change on growth depends on a country's export pattern, specifically the degree to which a country exports natural resources. Cravino and Sotelo (2017) show @@@.

Some analysis suggests that international trade plays only a small role in explaining the pattern of structural change on average. Kehoe, Ruhl and Steinberg (2016) find that for the United States, relatively faster manufacturing productivity growth primarily caused the reduction in goods employment, with a smaller role for trade deficits. Święcki (2016) also finds differential productivity growth is more important on average for explaining structural change than other mechanisms, including international trade. Nonetheless, even if international trade only contributes a small portion to structural change, we show that structural change plays a large role in the growth of world trade.

Non-homothetic preferences are important in understanding other aspects of international trade as well. Fieler (2011) finds that non-homothetic preferences can explain why trade grows with income per capita but not population. Simonovska (2015) shows that non-homothetic preferences can replicate the pattern that higher income countries have higher prices of tradable goods.

Finally, this paper also contributes to an earlier literature on how global trade grows relative to GDP. In an early theoretical contribution, Markusen (1986) includes non-homothetic preferences in a trade model to be consistent with empirical evidence of a relationship between income and trade volumes. Rose (1991) shows that increases in income and international reserves along with declines in tariff rates help explain the differences in trade growth across countries over three decades. Baier and Bergstrand (2001) find that income growth explains nearly two-thirds of the increase in global trade, with tariffs explaining an additional one-quarter. Imbs and Wacziarg (2003) document a U-shaped pattern of specialization as countries become richer, that they first diversify across industries and only later specialize as they grow. Yi (2003) shows how vertical specialization, the splitting of production stages across borders, can amplify gross trade relative to value-added trade and help explain the large increases in trade-to-GDP ratios.

The remainder of the paper is set up as follows. Section 2 describes the empirical counterfactual, while Section 3 sets up the general equilibrium model with endogenous trade and consumption shares. Section 4 describes the calibration and solution of the model, while Section 5 presents the quantitative results. Section 6 concludes.

2 Empirical Counterfactual

In this section, we present a simple reduced-form empirical exercise holding the global expenditure shares of goods and services fixed. This counterfactual will provide an idea of how important structural change, as defined by changes in expenditure shares, might be in affecting global trade growth, but it has some limitations that will be discussed in detail.

We begin with a few broad concepts, then discuss how we get at each concept using data for a large set of countries. First, structural change in this section refers to changes in the relative expenditure of goods and services as a share of total expenditure. Second, sectoral openness (or tradability) is defined as imports plus exports of a sector as a share of expenditure. For every country and for the world as a whole, we can decompose the trade (imports plus exports) over expenditure ratio of period t as

$$\frac{Trade_t}{Exp_t} = \frac{Trade_{gt}}{Exp_{gt}}\frac{Exp_{gt}}{Exp_t} + \frac{Trade_{st}}{Exp_{st}}\frac{Exp_{st}}{Exp_t}, \tag{1}$$

where g and s denote goods and services. Total expenditure of goods and services is $C+I+G$. Because global trade is balanced, global expenditure is equal to global GDP, but this is not true at the country or sector level. Clearly, both the evolution of sectoral openness measures and sectoral structural change (movements in expenditure shares) over time shape the aggregate openness measure.

To gauge the contribution of structural change to the world trade-expenditure ratio, we freeze the expenditure shares at the first period of data and compute a counterfactual trade over expenditure ratio as:

$$\frac{\widetilde{Trade_t}}{Exp_t} = \frac{Trade_{gt}}{Exp_{gt}}\frac{Exp_{g0}}{Exp_0} + \frac{Trade_{st}}{Exp_{st}}\frac{Exp_{s0}}{Exp_0}, \tag{2}$$

By holding the expenditure shares of sector k fixed, $\frac{Exp_{kt}}{Exp_t}$ at the start of the period, we shut down the process of structural change that happened in the data. The new counterfactual trade to expenditure ratio is free of structural change, but it is consistent with the observed sectoral openness measures. If the counterfactual trade-expenditure ratios are significantly different from the observed ratios, it suggests that structural change has an important impact on global trade.

2.1 Data

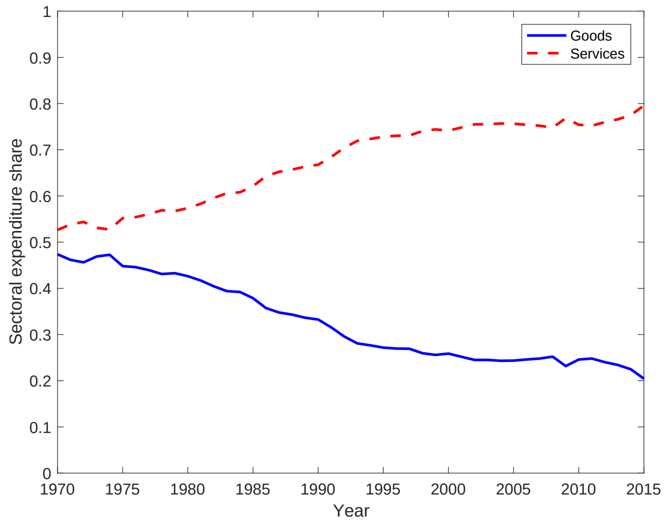
We gather data needed to compute the counterfactual in equation (2) for 27 countries over the period 1970-2015. The important pieces are comparable value-added production data for goods and services across countries, as well as imports and exports by each broad sectoral category. Input-output table coefficients allow us to calculate expenditure shares from value-added shares, a process detailed in the model section.

2.2 Results

We start by presenting the patterns of structural change in the world economy. Figure 1 plots the expenditure shares for goods and services across our sample of countries from 1970-2015. It shows a steady decline in the goods share until the early 2000s and a commensurate increase in the share of services. The share of the service sector rises by 27 percentage points from 53 percent in 1970 to 80 percent in 2015. Thus, there is substantial reallocation across sectors in the past four decades.

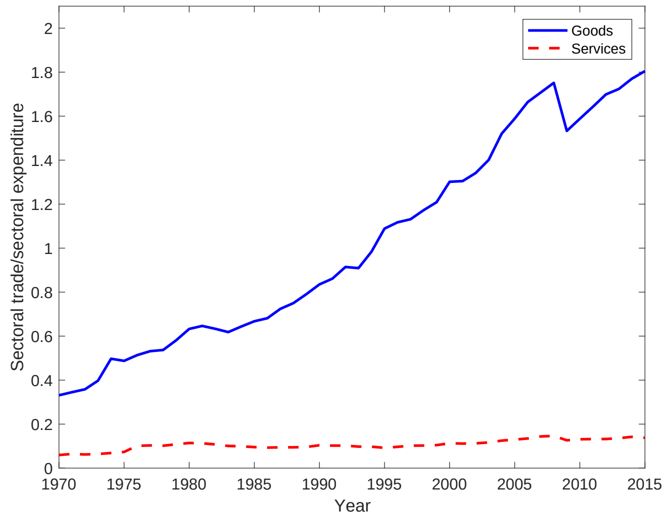
Note that structural change at a country level has generally continued since 2000. The stalling of sectoral change at a global level, however, is a largely a consequence of aggregation. As countries with a still-low level services share like China gain greater global weight, they drag down the global services expenditure share. We should expect that as structural change in China continues to follow the path of other countries, global structural change will resume in the future.

Figure 1: Aggregate Sectoral Expenditure Relative to Total



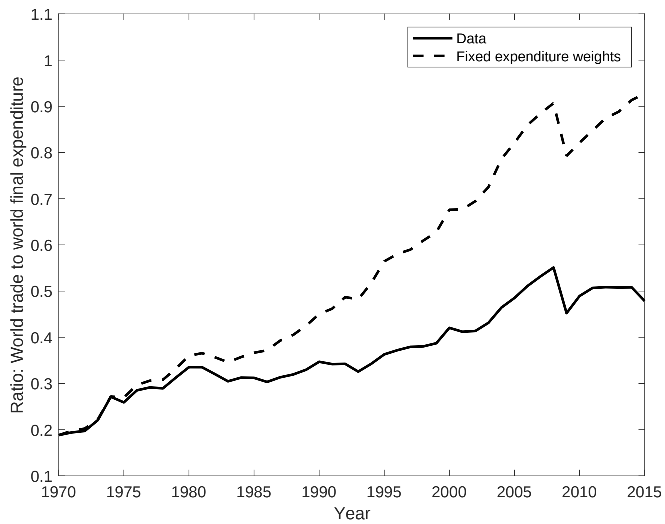
If sectoral openness is similar across sectors, regardless of how large structural change is across sectors, the impact of structural change on aggregate openness will be small. In the data, however, trade openness differs substantially across sectors. Figure 2 plots the sectoral trade over sectoral expenditure ratio over 1970-2015. Clearly goods are much more open than services; the trade-expenditure ratio is about 6 percent for services but 33 percent for goods in 1970. Over time, trade openness rises for both sectors, but it is much more pronounced for goods. By the end of the period, the trade-expenditure ratio is about 14 percent for services and 180 percent for goods.

Figure 2: Aggregate Trade to Expenditure Ratios by Sector



Now we look at the counterfactual trade openness as constructed in equation (2). For ease of comparison, Figure 3 contrasts the aggregate trade openness measure in the data with the one in the counterfactual, where sectoral value-added shares are fixed at 1970 levels. As can be seen, the gap between the counterfactual openness measure and the actual data widens substantially over the 1990s and early 2000s, indicating that without underlying movements towards less-tradable services, global trade growth would have been far higher. According to this exercise, structural change has lopped about 45 percentage points off the trade to expenditure ratio since 1970.

Figure 3: Aggregate Trade to Expenditure Ratio



Note: The data line is the aggregate trade to expenditure ratio for 27 countries and ROW listed in the data appendix. The counterfactual line holds the expenditure shares constant at the start of the sample.

Of course, this counterfactual is deficient in a number of ways. Most importantly, there is no outlet for any endogenous consumption responses as real income increases over time, which would certainly affect both trade and production patterns. In addition, the role of intermediate input usage – capital goods make up nearly 40% of world trade flows – and trade costs are all hidden in this exercise. Specifically, the degree to which goods and services have become more open over time is endogenous, and this exercise assumes that openness in the counterfactual would have occurred identically to the data. Thus, a more comprehensive exercise is needed to accurately quantify the impact of structural change on international trade more completely.

3 Model

We consider a multi-country model of the global economy in a two-sector Eaton Kortum trade model.[3] Household preferences have non-unitary income and substitution elasticities of demand. In each sector, there is a continuum of goods, and production uses both labor and intermediate inputs. All goods are tradable, but trade costs vary across sectors, country-pairs, and over time, to capture different trade intensities. Productivities also differ in initial levels and subsequent growth rates across sectors and countries; these forces drive structural change. We omit the time subscript unless needed.

[3]The model closely follows that of Sposi (2016), and greater detail of the model solution can be found in its appendix.

There are I countries, indexed by i and j. There are two sectors: goods (g) and services (s), indexed by k and n.

3.1 Preferences

The household in country i has a standard period utility function $U(C_i)$ over the aggregate composite good C_i. The aggregate composite consumption combines sectoral composite goods according to the implicitly defined function

$$\sum_{k=g,s} \omega_k^{\frac{1}{\sigma}} \left(\frac{C_i}{L_i}\right)^{\frac{\varepsilon_k-\sigma}{\sigma}} \left(\frac{C_{ik}}{L_i}\right)^{\frac{\sigma-1}{\sigma}} = 1, \tag{3}$$

where for each sector $k \in \{g,s\}$, C_{ik} is consumption of sector-k composite goods, and the preference share parameters ω_k's are positive and sum to one across sectors. The elasticity of substitution across sectoral composite goods is $\sigma > 0$. If $\sigma > 1$, the sectoral composite goods are substitutes, and if $\sigma \leq 1$, the sectoral composite goods are complements. ε_k denotes the income elasticity of demand for sector k.

These preferences are proposed by Comin et al. (2015). They show that this specification of nonhomothetic preferences has two attractive properties. First, the elasticity of the relative demand for the two sectoral composites is constant over aggregate consumption or income. In contrast to Stone-Geary nonhomothetic preferences, the elasticity of relative demand vanishes to zero as income or aggregate consumption rises, which is at odds with the empirical data both at the macro and micro levels. Second, the elasticity of substitution between sectoral composites is constant, given by σ, over income. They demonstrate that this specification has the potential to be flexible enough to capture the structural change patterns in the data.

The representative household maximizes his/her utility (3) subject to the following budget constraint in each period:

$$\underbrace{P_{ig}C_{ig} + P_{is}C_{is}}_{P_iC_i} + \rho_i w_i L_i = w_i L_i + RL_i, \tag{4}$$

where w_i and P_{ik} denote the wage rate and the price of the sector-k composite good, respectively, and P_i denotes the aggregate consumption price. The household supplies its unit labor endowment inelastically and spends its labor income on consumption. A fraction ρ_i of income is sent into a global portfolio, and the portfolio disperses, in lump sum, R equally across countries on a per-worker basis. Therefore, each country lends $\rho_i w_i L_i - RL_i$ to the rest of the world. This enables the model to match trade imbalances in the data, as in Caliendo, Parro, Rossi-Hansberg and Sarte (2016).

The first-order conditions imply that the consumption demand of sectoral goods satisfies, for any $k \in \{g, s\}$,

$$C_{ik} = L_i \omega_k \left(\frac{P_{ik}}{P_i} \right)^{-\sigma} \left(\frac{C_i}{L_i} \right)^{\varepsilon_k}, \tag{5}$$

where the aggregate price is given by

$$P_i = \frac{L_i}{C_i} \left[\sum_{k=g,s} \omega_k \left(\frac{C_i}{L_i} \right)^{\varepsilon_k - \sigma} P_{ik}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{6}$$

3.2 Technologies

There is a continuum of goods in the goods (g) and services (s) sectors. Each country possesses technologies for producing all the goods in all sectors. The production function for good $z \in [0,1]$ in sector $k \in \{g, s\}$ of country i is

$$Y_{ik}(z) = A_k(z)(T_{ik} L_{ik}(z))^{\lambda_{ik}} \left[\Pi_{n=g,s} M_{ikn}^{\gamma_{ikn}}(z) \right]^{1-\lambda_{ik}} \tag{7}$$

where A_{ik} denotes exogenous productivity, λ_{ik} denotes the country-specific value-added share in production, and γ_{ikn} denotes the country-specific share of intermediate inputs sourced from sector n. $Y_{ik}(z)$ denotes output, $L_{ik}(z)$ denotes labor, and $M_{ikn}(z)$ denotes sector-n composite goods used as intermediates in the production of the sector k good z. $A_k(z)$ is the realization of a random variable drawn from the cumulative distribution function $F(A) = Pr[Z \leq A]$. Following Eaton and Kortum (2002), we assume that $F(A)$ is a Fréchet distribution: $F(A) = e^{-A^{-\theta_k}}$, where $\theta_k > 1$. The larger is θ_k, the lower the heterogeneity or variance of $A_k(z)$.[4] The parameters governing the distribution of idiosyncratic productivity draws are invariant across countries but different across sectors. We assume that the productivity is drawn each period.[5]

When goods are shipped abroad, they incur trade costs, which include tariffs, transportation costs, and other barriers to trade. We model these costs as iceberg costs. Specifically, if one unit of good z is shipped from country j, then $\frac{1}{\tau_{ijm}}$ units arrive in country i. We assume that trade costs within a country are zero, i.e., $\tau_{iia} = \tau_{iim} = 1$.

Goods markets are perfectly competitive; goods prices are determined by marginal costs of production. The cost of an input bundle in sector k is $v_{ik} = w_i^{\lambda_{ik}} \left(\Pi_{n=g,s} (P_{in})^{\gamma_{ikn}} \right)^{1-\lambda_{ik}}$, which is the same within a sector, but varies across sectors given different input shares across sectors. The price at which country j can supply good z in sector k to country i equals $p_{ijk}(z) = \frac{\tau_{ijk} v_{jk}}{A_k(z) T_{ik}^{\lambda_k}}$. Since buyers will select to buy from the cheapest source, the actual price for this good in country i is

[4] $A_k(z)$ has geometric mean $e^{\frac{\gamma}{\theta_k}}$ and its log has a standard deviation $\frac{\pi}{\theta_k \sqrt{6}}$, where γ is Euler's constant.

[5] Alternatively, we could assume that the productivity is drawn once in the initial period, and as the T's change over time, the productivity relative to T remains constant.

$p_{ik}(z) = \min\{p_{i1k}(z), p_{i2k}(z)\}$.

The composite good in each sector Q_{ik} is an aggregate of the individual goods $Q_{ik}(z)$:

$$Q_{ik} = \left(\int_0^1 Q_{ik}(z)^{\frac{\eta-1}{\eta}} dz \right)^{\frac{\eta}{\eta-1}},$$

where the elasticity of substitution across goods within a sector is $\eta > 0$. Each good z is either produced locally or imported from abroad. The composite sectoral goods are used in domestic final consumption, C_{ik}, and domestic production as intermediate inputs.

Under the Fréchet distribution of productivities, Eaton and Kortum (2002) show that the price of composite good $k \in \{g, s\}$ in country i is

$$P_{ik} = \Gamma \left(\Phi_{ik}\right)^{-\frac{1}{\theta_k}},$$

where the constant Γ is the Gamma function evaluated at $\left(1 - \frac{\eta-1}{\theta_k}\right)^{\frac{1}{1-\eta}}$, and $\Phi_{ik} = \sum_{j=g,s} \left(T_{jk}^{-\lambda_{jk}} v_{jk} \tau_{ijk} \right)^{-\theta_j}$. Φ_{ik} summarizes country i's access to global production technologies in sector k scaled by the relevant unit costs of inputs and trade costs.[6]

The share of country j's expenditure on sector-k goods from country i, π_{jik}, equals the probability of importing sector-k goods from country i in country j, and is given by

$$\pi_{jik} = \frac{\left(A_{ik}^{-\lambda_{ik}} v_{ik} \tau_{jik} \right)^{-\theta}}{\Phi_{jk}}. \tag{8}$$

Equation (8) shows how a higher average productivity, a lower unit cost of input bundles, and a lower trade cost in country i translates into a greater import share by country j.

3.3 Equilibrium

All factor and goods markets are characterized by perfect competition. Labor is perfectly mobile across sectors within a country, but immobile across countries. Let L_i denote total labor endowment in country i and L_{ik} denote labor employed in sector k. The factor market clearing conditions in each period are given by

$$L_i = L_{ig} + L_{is}. \tag{9}$$

[6] We need to assume $\eta - 1 < \theta$ to have a well-defined price index. Under this assumption, the parameter η, which governs the elasticity of substitution across goods within a sector, can be ignored because it appears only in the constant term Γ.

We next characterize the market clearing condition. For each sector k, we have

$$Q_{ik} = C_{ik} + \sum_{n=g,s} (1 - \lambda_{in})\gamma_{ink} \sum_{j=1}^{I} \frac{\pi_{jin} P_{jn} Q_{jn}}{P_{ik}}. \tag{10}$$

That is, the quantity of sector-k composite goods produced in country i, Q_{ik}, is the sum of the quantity demanded (i) for domestic final consumption C_{ik}; (ii) for use as intermediate inputs in the production of domestic goods and services, $\sum_{n=g,s}(1-\lambda_{in})\gamma_{ink}\sum_{j=1}^{I}\frac{\pi_{jin}P_{jn}Q_{jn}}{P_{ik}}$. These market clearing conditions demonstrate that our model captures two key features of the world economy. First, the model allows trade in intermediates, as much of world trade is in intermediates. Second, the model captures two-way input linkages across sectors.

We define a competitive equilibrium of our model economy with labor endowment processes $\{L_i\}$, trade cost processes $\{\tau_{ijg}, \tau_{ijs}\}$, productivity processes $\{A_{ig}, A_{is}\}$, exogenous process for contribution shares to the global portfolio ρ_i, time-varying structural parameters $\{\lambda_{ik}, \gamma_{ikn}\}$ and time-invariant structural parameters $\{\sigma, \varepsilon_k, \omega_k, \theta_k\}$ as follows.

Definition 1. *A competitive equilibrium* is a sequence of output and factor prices $\{P_{ig}, P_{is}, P_i, w_i\}_{i=1}^{I}$, allocations $\{L_{ig}, L_{is}, Q_{ig}, Q_{is}, C_{ig}, C_{is}\}_{i=1}^{I}$, transfers from the global portfolio, R, and trade shares $\{\pi_{ijg}, \pi_{ijs}\}_{i,j=1,..I}$, such that, given prices, the allocations solve the firms' maximization problems associated with technologies (7) and the household's maximization problem characterized by (3)–(4), the global portfolio is balanced, and satisfy the market clearing conditions (9)–(10).

4 Calibration and Solution

To quantify the role of structural change in global trade flows, we calibrate the exogenous processes and parameters in the model using the data. We adopt the estimated world values of the preference parameters from Sposi (2016).[7] We normalize the income elasticity $\varepsilon_g \equiv 1$, which for a given aggregate price index P_i pins down sectoral prices P_{ik} consistent with the expenditure shares. We set $\varepsilon_s = 1.19$ and $\sigma = 0.40$, implying that goods and services are complements. The Fréchet shape parameter $\theta = 4$, in line with Simonovska and Waugh (2014).

Our solution method for the model takes the following form. First, we bring in the key data for the model: $\pi_{ijkt}, \gamma_{iknt}, P_i, w_i, \lambda_{ikt}$. We then calculate sectoral prices P_{ik} consistent with the non-homothetic preferences. Next, we back out values for the key model unobservables from the equilibrium conditions for T_{ikt}, τ_{ijkt}. With these in hand, we can solve the baseline model completely in levels for each year $t = \{1970, 2015\}$. We then compute the counterfactual model with no structural change by setting $\sigma = \varepsilon_k = 1$.

[7] He estimates the income elasticity of services relative to manufacturing, which we take as the elasticity of services relative to all goods, as the share of agriculture in expenditure and value-added for most countries is quite small.

4.1 Observables

First, we account for as many observables as we can for as many countries as we can with reliable cross-country data.

We begin with the estimates of γ_{iknt} and λ_{ikt}. Both of these parameters come from the World Input-Output Database (WIOD), condensed down to a two-sector input-output database for each year from 1995-2011. λ_{ikt} is simply the ratio of value added to total production in sector k, while the γ_{iknt} terms are the share of sector k inputs that are sourced from sector n. Both are available immediately from the input-output table.

Recall that π_{ijkt} is the amount of sector k output sent from j to i as a fraction of total production. To construct the numerator, we use bilateral trade data for goods data from IMF Direction of Trade Statistics where unavailable in the WIOD, and bilateral service trade data from a combination of WIOD, OECD, and WDI. In years where no bilateral data is available, we apply bilateral shares from the most recent year to aggregate WDI service imports. The denominator is constructed as production minus exports plus imports; gross production data for a sector is generated from UNdata value added data "grossed up" using our estimates of λ_{ikt}.

4.2 Solving the Model

There are a number of key equations needed to solve the model.

The input cost equation:

$$v_{ik} = w_i^{\lambda_{ik}} \left(\prod_{n=g,s} P_{in}^{\gamma_{ikn}} \right)^{1-\lambda_{ik}}, \tag{11}$$

The state of technology in sector k of country i:

$$\Phi_{ik} = \sum_{j=1}^{N} T_{jk} \left(v_{jk} \tau_{ijk} \right)^{-\theta}, \tag{12}$$

Sector prices:

$$P_{ik} = \Gamma \left(\Phi_{ik} \right)^{-\frac{1}{\theta}}.$$

The model-implied trade share equations for trade of sector k from country j to i:

$$\pi_{ijk} = \frac{T_{jk} \left(v_{jk} \tau_{ijk} \right)^{-\theta}}{\Phi_{ik}} = \frac{T_{jk} \left(v_{jk} \tau_{ijk} \right)^{-\theta}}{\Gamma^{\theta} P_{ik}^{-\theta}}. \tag{13}$$

The share of domestic absorption:

$$q_{ikt} = \frac{P_{ikt} Q_{ikt}}{w_{it} L_{it}}.$$

The share of labor going to each sector k:

$$l_{ik} = \frac{\lambda_{ik} \sum_{j=1}^{I} \pi_{jik} P_{jk} Q_{jk}}{w_i L_i} = \lambda_{ik} \sum_{j=1}^{I} \frac{w_j L_j}{w_i L_i} \pi_{jik} q_{jk}. \tag{14}$$

The share of the domestic absorption of sector k in the total wage bill:

$$q_{ik} = \frac{P_{ik} Q_{ik}}{w_i L_i} = e_{ik} + \sum_{n=g,s} \frac{1-\lambda_{in}}{\lambda_{in}} \gamma_{ink} l_{in}. \tag{15}$$

The equilibrium expression for wages via labor market clearing:

$$w_i = \sum_{k=g,s} \lambda_{ik} \sum_{j=1}^{I} \frac{w_j L_j}{L_i} \pi_{jik} q_{jk}. \tag{16}$$

Global portfolio balance:

$$R = \frac{\sum_i \rho_i w_i L_i}{\sum_i L_i}.$$

Relationship between wages and prices:

$$w_i^{1-\sigma} = \sum_{k=g,s} \omega_k \left(\frac{w_i}{P_i}\right)^{\varepsilon_k - \sigma} P_{ik}^{1-\sigma}.$$

And finally, the expression for expenditure share on sector k:

$$e_{ik} = \frac{P_{ik} C_{ik}}{w_i} = \omega_k \left(\frac{P_{ik}}{P_i}\right)^{1-\sigma} \left(\frac{w_i}{P_i}\right)^{\varepsilon_k - 1}.$$

5 Model-based Counterfactual

5.1 Setup

To examine the implications on global trade flows of structural change, we construct the counterfactual in which structural change is absent. That is, assume that the preferences in the counterfactual is given by

$$C_i = \sum_{k=g,s} \omega'_{ik} log C_{ik} \tag{17}$$

With this specification, the expenditure shares across sectors are constant, given by ω'_{ik} to match the country specific initial-period sector expenditure share. That is,

$$e_{ikt} = e_{ik0} \tag{18}$$

Also the aggregate price index is given by

$$P_{it} = \Pi_{k=g,s} P_{ikt}^{\omega'_k}. \tag{19}$$

All other equations that characterize the equilibrium in the counterfactual are identical to those in the baseline.

To be more specific, in the counterfactual we assume all other parameters and time varying processes for T, τ, and L unchanged from the baseline, except that the preferences parameters $\{\sigma, \varepsilon_k, \omega_k\}$ in the baseline are set to $\{1, 1, \omega'_{ik}\}$ in the counterfactual experiment. We can solve the counterfactual in changes as follows.

1. Guess $\{w_i\}_{i=1}^{I}$.
   - Compute sectoral prices for all country i and sector k iteratively, using
   $$P_{ikt}^{-\theta} = \sum_{j=1}^{N} \pi_{ijk0} T_{jkt} \tau_{ijkt}^{-\theta} w_{jt}^{-\theta\lambda_{jk}} \left(\prod_{n=g,s} P_{jnt}^{\gamma_{jkn}} \right)^{-\theta(1-\lambda_{jk})}. \tag{20}$$
   - Compute the unit cost v_{ikt} and the total technology access Φ_{ikt} using equation (11) and (12), respectively.
   - Compute the trade shares π_{ijkt} as in equation (13).
   - Expenditure shares e_{ikt} fixed at their 1970 value.
   - Sectoral absorption ratios q_{ikt} are given by equation (15).
   - Compute the labor shares l_{ik} from equation (15).
   - Compute the aggregate price P_{it} given by equation (19).
2. Update $\{w'_i\}$ using equation (16).
3. Repeat the above procedure until $\{w'_i\}$ is sufficiently close to $\{w_i\}$.

5.2 Results

Figure 4: Global Trade to Expenditure Ratio

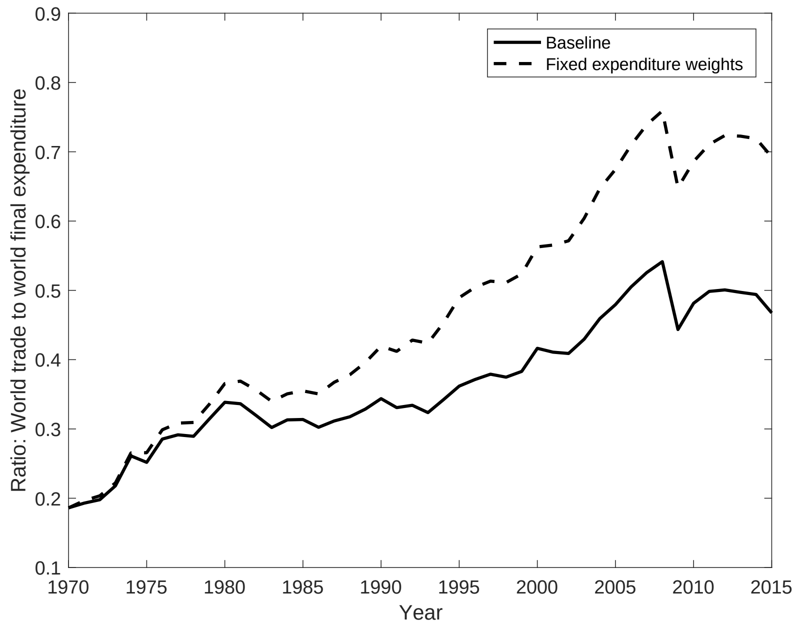
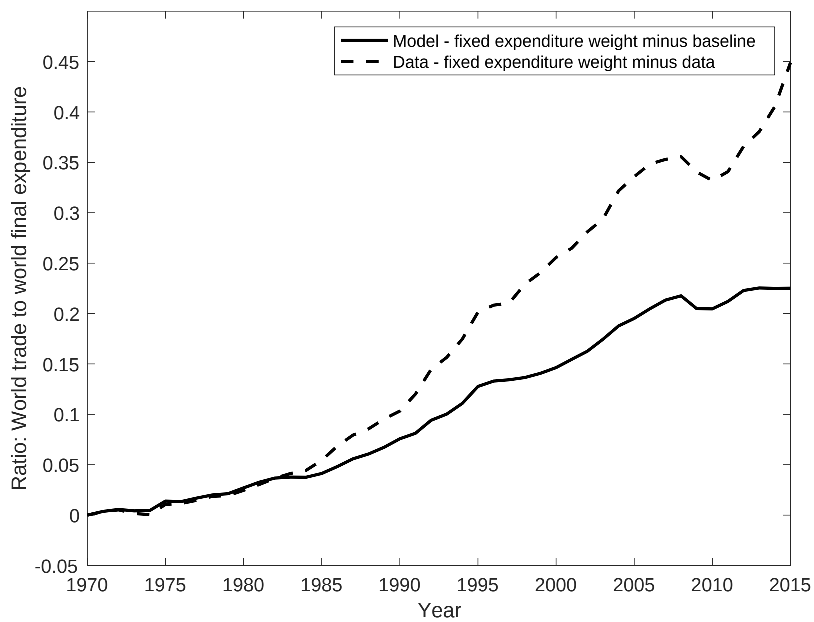


Figure 4 shows the ratio of global trade to global expenditure in the baseline model and the model counterfactual holding expenditure weights constant in each country. As with the reduced form counterfactual in Figure 3, global trade would have been much higher had structural change not occurred. The model-based counterfactual is about one-half higher than the baseline.

Figure 5: Empirical versus Model-based Counterfactual



In Figure 5, we compare the reduced-form and model-based counterfactual in percentage point terms. The counterfactuals are very similar and fairly small until the late 1980s, after which the reduced-form counterfactual implies very strong trade growth. By 2015, the reduced-form counterfactual is about 45 percentage points while the model-based counterfactual is about 23 percentage points. The difference between the two counterfactuals peaks at about 22 percentage points in 2015 and is driven by the endogenous changes to sectoral openness generated by the model.

Figure 6: Goods share in World Expenditure

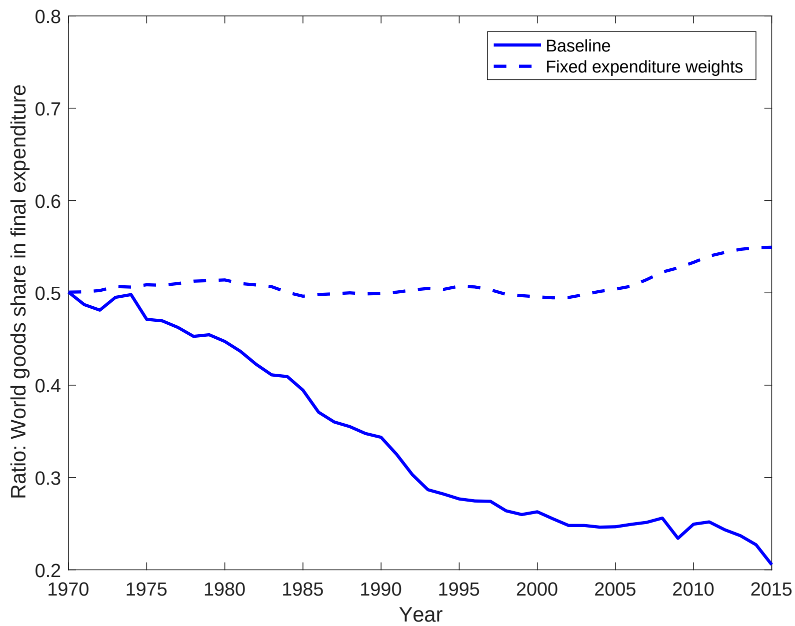
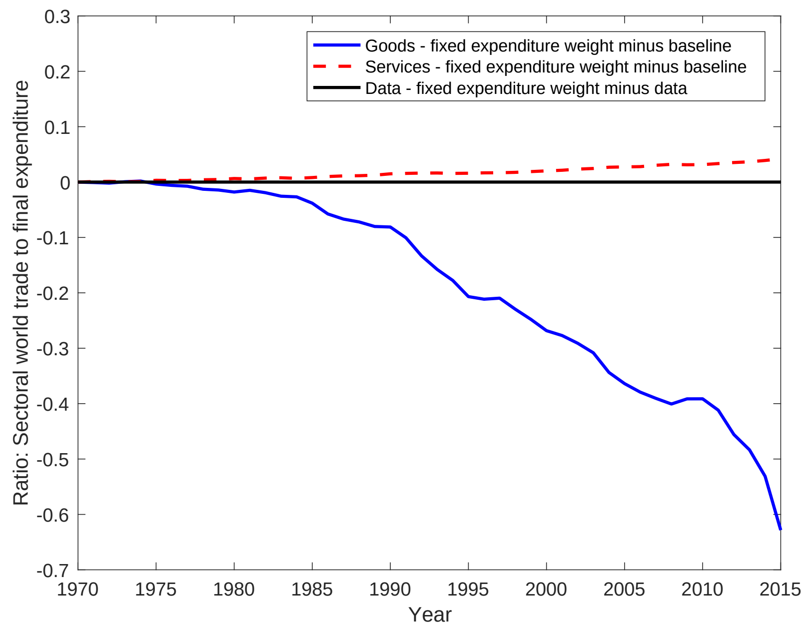


Figure 6 shows the driving force of the counterfactual: in the baseline, the goods share of total expenditure falls from about 50 percent to 20 percent. In the counterfactual, goods expenditure is held fixed country-by-country. When aggregated globally, the share remains quite close to 50 percent on average.

Figure 7: Sector Trade Shares Relative to Baseline



The key difference between the reduced-form counterfactual and the model-based one is that in the reduced-form counterfactual, sectoral openness follows the same path as the data. Figure 7 shows how sectoral openness in the model-based counterfactual deviates from baseline sectoral openness. The blue line shows that goods openness (goods trade as a share of goods expenditure) falls by about 60 percentage points relative to the baseline, while services openness rises by about 5 percentage points. To understand the endogenous responses of sectoral trade in the model, it is helpful to decompose sectoral trade into two terms: one of trade as a share of absorption and a second of absorption as a share of expenditure:

$$\frac{Trade_{kt}}{Exp_{kt}} = \frac{Trade_{kt}}{Abs_{kt}} \frac{Abs_{kt}}{Exp_{kt}}. \tag{21}$$

Figure 8: Sector Trade and Absorption Relative to Baseline

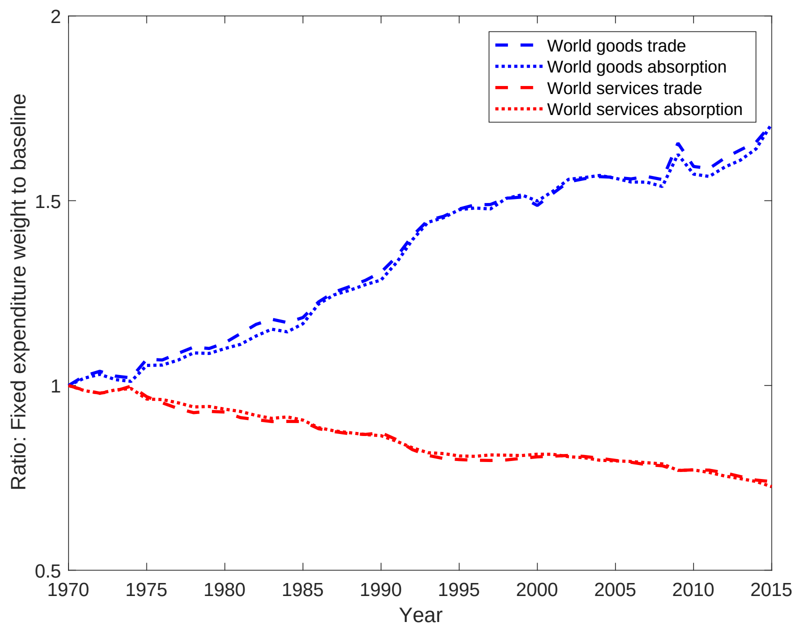
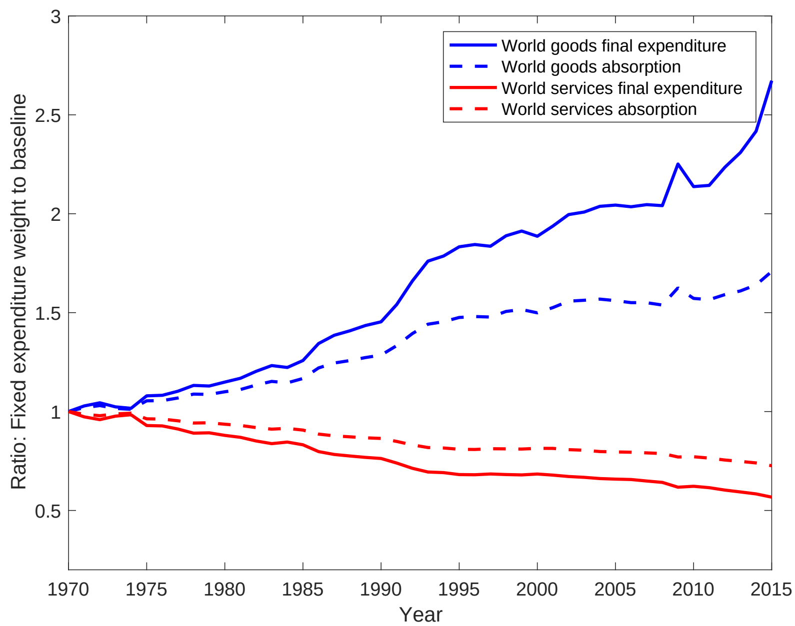


Figure 8 shows the growth of trade and absorption in each sector in the model-based counterfactual relative to the baseline. With the higher level of goods expenditure fixed, both goods trade and goods absorption rise about 70 percent, and services fall about 30 percent. So the mix of domestic goods and traded goods remains similar to the baseline.

Figure 9: Expenditure and Absorption Relative to Baseline



On the other hand, Figure 9 shows final expenditure and absorption in each sector for the model-based counterfactual relative to the baseline. Here, we see that goods expenditure rises about 150 percent and services expenditure falls about 50 percent, much more than absorption. This points to the input-output linkages in the model as the key to understanding a reduction in goods openness in the model-based counterfactual.

Figure 10: Sector Trade and Absorption without I-O Linkages

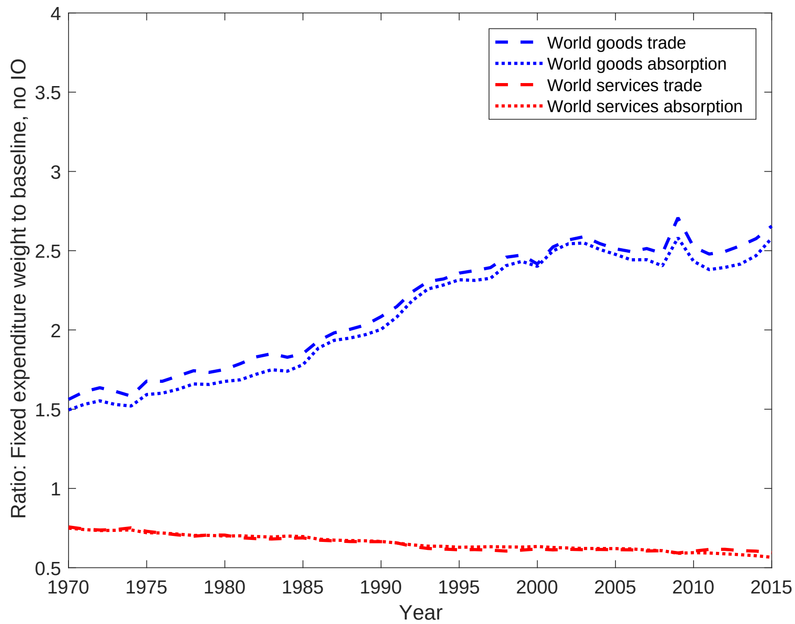
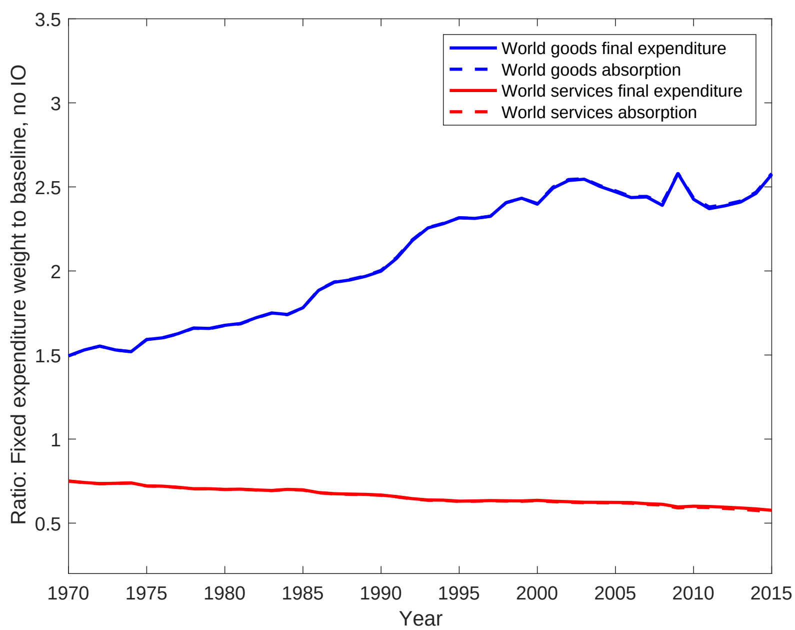


Figure 11: Expenditure and Absorption without I-O Linkages



In Figure 10, we recalculate the baseline and counterfactual in a world with no input-output linkages between sectors ($\gamma_{gg} = \gamma_{ss} = 1$). Once again, we see that goods trade increases similarly to goods absorption, and in Figure 11 we see that goods final expenditure must change equally with goods absorption. In other words, goods trade as a share of goods expenditure falls in the model-based counterfactual primarily because the input-output linkages imply that increasing goods expenditure requires some services; this means that goods trade will not increase one-for-one with goods expenditure. While Figure 7 shows that services openness does rise because of this intermediate input requirement, it is insufficient to offset the fall in goods openness. So relative to the reduced-form counterfactual in which sectoral openness is taken from the data, the model-based counterfactual implies a somewhat smaller increase in the global trade-to-expenditure ratio.

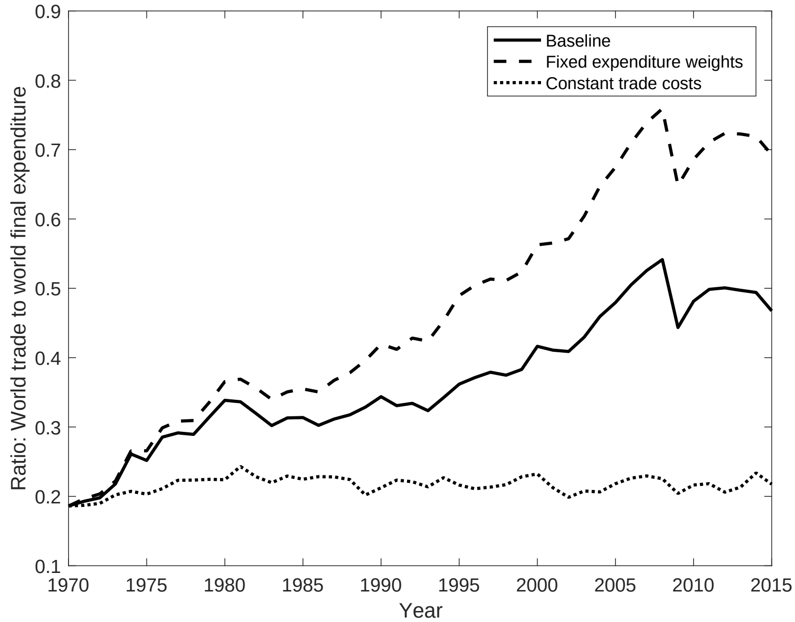
5.3 The growth of world trade

In the model, global trade-to-expenditure can grow from several sources: trade costs, differential productivity changes, and changing input-output linkages (vertical specialization). In Figure 12, we show that the growth in world trade is largely driven by a reduction in trade costs. The dotted line shows a counterfactual in which trade costs are held at their 1970 level, and in this world, the global trade-to-expenditure ratio grows only modestly.

Of course, trade costs in the baseline model are calculated as the residuals required to account for changes in trade not driven by technology or demand. As such, they incorporate a wide variety of economic forces, including tariff reductions, improvements in shipping technology, or even compositional changes in demand at a finer level of disaggregation than our goods and services distinction.

That said, the constant trade cost counterfactual also demonstrates the quantitative significance of structural change: structural change has held back trade by roughly the same magnitude as reductions in trade costs have boosted trade as a share of expenditure over these four decades.

Figure 12: World Trade to Expenditure Ratio



6 Conclusion

We show that structural change from goods to services over time has been a significant drag on global trade growth over the last four decades. In the absence of structural change, defined as a fixed expenditure share in goods and services at their 1970 level, the global trade-to-expenditure ratio would be 23 percentage points or 48 percent higher. We estimate this counterfactual with a structural model incorporating comparative advantage, non-homothetic preferences, and an input-output structure.

We define structural change as holding constant sectoral expenditure shares by turning off the income and price elasticities defined in the non-homothetic preferences. With a higher share of goods expenditure, the global trade-to-expenditure ratio will be much higher than in the data. However, goods trade as a share of goods expenditure is actually somewhat lower than in the data: goods expenditure rises substantially in the counterfactual, but because goods requires some services inputs through the input-output structure, it does not rise in equal measure. This means that relative to a simple empirical counterfactual holding expenditure shares fixed but letting sectoral openness change as in the data overstates the importance of structural change on trade.

Though structural change has been a significant drag on global trade growth over recent decades, it has not been a particularly strong drag since the global financial crisis. Instead, the recent slowdown in trade can be attributed to a lack of factors that have historical caused trade to rise as a share of expenditure.

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A Data appendix

For the empirical counterfactual, we need value-added and trade by sector (goods and services). Our sample includes 27 countries in WIOD for which sufficiently long data are available, plus a rest of world aggregate to ensure that global trade is balanced. The list of countries is Australia, Austria, Belgium-Luxembourg, Brazil, Canada, China, Cyprus, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Portugal, Spain, Sweden, Turkey, United Kingdom, and United States.

Value added data are obtained from UN (2017). Bilateral and aggregate goods trade data are obtained from the IMF Direction of Trade Statistics database (IMF 2016).

Input-output tables for 1995-2011 are obtained from the World Input-Output Database (Timmer, Dietzenbacher, Los, Stehrer and de Vries 2015). For years before and after those available in WIOD, we take parameter values from 1995 and 2011, respectively. Of particular note is that we define construction as a services category.[8]

[8] Results are qualitatively similar defining construction as a goods category, but given the lack of direct trade in construction, categorizing it as a service will make goods sectoral openness lower and services sectoral openness higher. Both the model-based counterfactual and especially the empirical counterfactual would be smaller in magnitude relative to the data.