Bilateral Trade Imbalances*

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Abstract

In standard quantitative models, bilateral trade imbalances are determined by aggregate trade imbalances, expenditure and production patterns, and trade wedges. We calibrate such a model using recent data on incomes, factor endowments, and sector-level expenditures, outputs and bilateral trade flows for 40 economies and the rest of the world. Large pairwise asymmetries in trade wedges are needed for the model's bilateral-trade predictions to match the data. They account for 21-35% of the standard deviation of bilateral trade imbalances. Aggregate imbalances play a minor role, while more than 50% of the variation is explained by international differences in production and expenditure patterns.

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1 Introduction

It is a well-known fact that the U.S. trade balance has been in deficit every year since 1992. In the five years between 2010 and 2014, that deficit amounted to 2.8% of GDP. What is perhaps less well known is that the overall U.S. deficit masks significant heterogeneity of its trade balance with individual partner countries. The vertical bars in Figure 1 represent the U.S. trade balance (as a percentage of U.S. GDP) vis-à-vis 39 other economies and the rest of the world (RoW) over the period 2010-2014.[1] There is significant variation in U.S. bilateral balances around their average value, represented by the thick horizontal line.[2] The U.S. runs large bilateral deficits with China, and its NAFTA partners Mexico and Canada − but it also runs small trade surpluses with a number of other economies, including Ireland, the Netherlands and France.

[Insert Figure 1 here]

Such dispersion in a country's bilateral balances with its trade partners is not peculiar to the U.S. case. Each light-blue dot in Figure 2 represents the trade balance of the horizontal-axis country with one of its trade partners (as a percentage of the horizontal-axis country's GDP). The large black dot represents the horizontal-axis country's average bilateral balance. As the figure shows, the differences between the bilateral balances of individual countries with their partners are significantly larger than the differences in average bilateral balances *across* countries. Yet so far there exists no formal study which attempts to account for the large observed variation in trade balances across country pairs − despite the fact that specific examples of major imbalances between trade partners are a recurrent trigger of political controversies.[3]

[Insert Figure 2 here]

The present paper seeks to fill this gap in the literature. We combine a standard quantitative trade model with sectoral-level data on production, spending and trade for 40 countries and the rest of the world from the World Input Output Database (WIOD). We take countries' overall trade balances as given and calibrate the model's parameters to match observed expenditure and production patterns, and sector-level bilateral trade flows. Through a sequence of counterfactuals, we illustrate that the

[1] The figure is based on data from the 2016 release of the World Input-Output Database (WIOD). Section 3 discusses our data sources in detail.

[2] Since the data represented in Figure 1 covers the total value of all U.S. exports and imports divided across 40 countries/regions, the average bilateral trade balance equals the overall U.S. trade balance divided by 40.

[3] In the last three decades, the U.S. trade deficit vis-à-vis Japan (Janow, 1994), China (Feenstra et al., 1998; Hughes, 2005) and, most recently, Germany (Swanson, 2017; Krugman, 2017) has been in the spotlight as a possible symptom of unfair trade practices on the part of these countries against American producers.

calibrated model can account for *most* of the variation in bilateral trade balances as a result of observed differences in country's aggregate trade balances, spending patterns and industrial structure. Nevertheless, the origins of a significant portion of the variation in bilateral balances remain unexplained − and our model attributes them to pairwise asymmetric impediments to trade.

There are three possible reasons why trade balances may vary across country pairs. First, differences in aggregate trade balances may give rise to pairwise differences in bilateral balances: by definition, overall-deficit countries (such as the U.S.) will have a deficit with their average trade partner; overall-surplus countries (such as China) will have a surplus. Everything else constant, we would thus expect a deficit-surplus pair to have a larger trade imbalance than two surplus or two deficit countries. Second, differences in sectoral expenditure and production patterns may give rise to bilateral imbalances: if a large portion of Dutch expenditure is dedicated to goods produced by the U.S., a large portion of German expenditure to goods produced by the Netherlands, and a large portion of U.S. expenditure to goods produced by Germany, the resulting "triangular trade" may give rise to bilateral imbalances even in the absence of overall trade surpluses and deficits. Third and finally, systematically asymmetric obstacles to trade between two countries may penalise bilateral trade flows in one direction more than in the other.

Our calibrated model allows us to capture all three explanations for bilateral trade imbalances. We allow for aggregate trade imbalances which perfectly match countries' aggregate surpluses and deficits as observed in the data. We then use the model's preference and technology parameters to explain as much of countries' sector-level patterns of spending, production and trade as possible. The remaining gap between the model and the data is ascribed to the presence of broadly defined trade "wedges" at the country-pair-sector level. These wedges may represents technological and policy barriers to trade, as well as preference differences across countries which could reduce the gains from trade in some sectors. Our calibration treats them as a "residual," explaining the portion of the value of a country's import from its trade partner which cannot otherwise be accounted for. In order to match all flows of goods and services perfectly, we need to allow for these wedges to be potentially asymmetric: in a given sector, the import trade friction faced by one country from another may differ from the friction faced by the second from the first.

In a standard quantitative trade model, these three features of the data span all possible explanations for (differences in) bilateral trade imbalances: if there were no aggregate trade surpluses and deficits, if all countries' production and expenditure patters were the same, and if trade wedges were symmetric within country pairs, all bilateral balances would be identically equal to zero. By means of counterfactuals, our calibrated model allows us to assess the relative importance of the three. We find that international differences in production and spending patterns account for just over half of the observed variation in bilateral trade imbalances, while aggregate trade surpluses and deficits account for only a small portion (10-24%). The second-largest share of the variation in bilateral balances (21-35%) must be attributed to asymmetric trade wedges. These asymmetries appear to grow with the distance between country pairs, and are significantly smaller between EU member countries, suggesting that they may − in part − capture technological and policy-related impediments to trade.

Interpreting our trade wedges as barriers to trade arising from transport costs and trade policies, we analyse the impact on countries' welfare of a counterfactual move to symmetric trade barriers. The resulting welfare changes are sizeable, even for larger economies such as Germany and the U.K. However, the direction of the welfare changes militates against the popular narrative whereby bilateral deficits reflect "a bad deal" for the deficit country: countries whose inward trade costs are systematically lower than their outward trade costs are made *worse off* by a move to symmetric frictions. For example, our counterfactual shows that symmetric trade barriers would significantly reduce most large U.S. bilateral deficits − while also reducing U.S. consumption possibilities by raising the prices of imported goods.

Bilateral trade imbalances have received surprisingly little attention in academic research. Two notable exceptions are Feenstra et al. (1998), and Davis and Weinstein (2002). Feenstra et al. (1998) focus exclusively on the case of the U.S. trade deficit with China, whereas Davis and Weinstein (2002) analyse bilateral imbalances for a large sample of countries. Their work is most closely related with ours. The authors provide rough calculations of "theory-predicted" bilateral imbalances, relying on the gravity model of trade, and contrast them with the actual imbalances observed in the data. As we show in Section 2 below, their calculations are not inconsistent with the theoretical framework we employ − in which the values of sector-level trade flows between countries also obey a gravity equation −, but they are incomplete since their gravity equation is not derived from a fully microfounded quantitative model.[4] Moreover, Davis and Weinstein focus exclusively on trade in goods, while use of WIOD data allows us to cover the total value of countries' imports and exports of both goods and services.

Our work belongs to a large and growing strand of research, reaching back to Eaton and Kortum (2002), which uses calibrated quantitative models of international trade to analyse the relationship between countries' sector-level productivities, bilateral trade costs and real incomes. Several papers in this literature − including Dekle et al. (2007, 2008), Eaton et al. (2016a), and Cuñat and Zymek (2017) − explore

[4]Anderson (1979), and Anderson and van Wincoop (2003) were the first to show that model-consistent gravity equations feature so-called "multilateral resistance terms" − reflecting differences in price levels faced by different countries −, and that their omission may significantly alter the findings derived from applying the gravity equation to empirical data.

the impact of (changes in) *aggregate* trade imbalances on countries' incomes. Some analyse the impact of (changes in) trade costs on *aggregate* trade imbalances – see Reyes-Heroles (2015) and Eaton et al. (2016b). Yet to the best of our knowledge, none explore the determinants of *bilateral* trade imbalances.

Waugh (2010), in a study from this literature which abstracts from trade imbalances all together, shows that asymmetric trade barriers between rich and poor countries can help better reconcile quantitative trade models with countries' observed aggregate import shares. He shows that removing them would potentially reduce international income differences significantly. Our findings are complementary to Waugh's (2010), insofar as they show that asymmetric trade costs are also an important explanation for countries' observed bilateral trade imbalances. Moreover, we find that such asymmetries may not only shape aggregate trade between rich and poor countries, but also sector-level trade patterns between developed economies.

The remainder of the paper is structured as follows. Section 2 presents the theoretical model that serves as the basis for our analysis. Section 3 describes our data sources and calibration strategy. Section 4 motivates and carries out our counterfactual experiments. Section 5 offers a brief summary and concluding remarks.

2 Model

2.1 Preferences, Technologies and Market Structure

There are many countries, denoted by $n = 1, ..., N$, and many industries, denoted by $i = 1, ..., I$. The representative consumer in n maximises non-traded aggregate final consumption

$$C_n = \prod_{i=1}^{I} \left(\frac{C_{in}}{\beta_{in}} \right)^{\beta_{in}}, \tag{1}$$

where $\beta_{in} \in (0, 1)$, $\sum_i \beta_{in} = 1$. C_{in} denotes consumption of a non-traded industry-specific consumption good made of country-industry-specific goods:

$$C_{in} = \left(\sum_{n'=1}^{N} \omega_{in'n}^{\frac{1}{\sigma_i}} c_{in'n}^{\frac{\sigma_i - 1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i - 1}}, \tag{2}$$

where $\sigma_i \geq 1$, $\omega_{in'n} \geq 0$; $c_{in'n}$ represents consumption in industry i by n of good produced by n'.

Countries receive income from their endowments of two production factors – physical capital, K_n, and labour, L_n – as well as from possible net transfers from abroad, $T_n = -NX_n$, where NX_n denotes country n's net exports. Hence, the representative agent in n maximises (1) subject to

$$\sum_{i=1}^{I}\sum_{n'=1}^{N} p_{in'n}c_{in'n} \leq r_n K_n + w_n L_n + T_n, \tag{3}$$

where $p_{in'n}$ is the price of the country-n', industry-i good in n, r_n and w_n respectively denote the returns to capital and labor, and $\sum_n T_n = 0$.[5]

Industry i in country n uses production technology

$$Q_{in} = Z_{in}\left(\frac{K_{in}^{\alpha_n}H_{in}^{1-\alpha_n}}{\mu_{in}}\right)^{\mu_{in}}\left[\frac{1}{1-\mu_{in}}\prod_{i'=1}^{I}\left(\frac{X_{i'in}}{\beta_{i'n}}\right)^{\beta_{i'n}}\right]^{1-\mu_{in}}, \tag{4}$$

where $\alpha_n, \mu_{in} \in (0,1)$. K_{in} and $H_{in} \equiv h_n L_{in}$ respectively represent the capital and the labour in efficiency units used to produce the country-n, industry-i good; h_n captures labour productivity in country n; shifter Z_{in} describes the efficiency of production in industry-i, country-n; and

$$X_{i'in} \equiv \left(\sum_{n'=1}^{N}\omega_{i'n'n}^{\frac{1}{\sigma_{i'}}}x_{i'in'n}^{\frac{\sigma_{i'}-1}{\sigma_{i'}}}\right)^{\frac{\sigma_{i'}}{\sigma_{i'}-1}} \tag{5}$$

is a non-traded aggregator of intermediate inputs, where $x_{i'in'n}$ is the use by industry i in country n of the industry-i' good produced by country n'.

Goods and factor markets are perfectly competitive. International trade is subject to iceberg transport costs: $d_{in'n} \geq 1$ units of the country-n', industry-i good must be shipped for one unit to arrive in country n. Production factors can move freely between activities within countries, but cannot move across borders.

2.2 Equilibrium

We define country-n factor costs as

$$f_n \equiv \frac{1}{h_n^{1-\alpha_n}}\left(\frac{r_n}{\alpha_n}\right)^{\alpha_n}\left(\frac{w_n}{1-\alpha_n}\right)^{1-\alpha_n}. \tag{6}$$

The price for country n of a unit of industry-i, country-n' good is then

$$p_{in'n} = d_{in'n}p_{in'} \equiv \frac{d_{in'n}}{Z_{in'}}f_{n'}^{\mu_{in'}}\left(\prod_{i=1}^{I}P_{in'}^{\beta_{in'}}\right)^{1-\mu_{in'}}, \tag{7}$$

[5]Following Dornbusch et al. (1977), we use exogenous income transfers to allow for trade imbalances in a static model.

where

$$P_{in} \equiv \left(\sum_{n'=1}^{N} \omega_{in'n} p_{in'n}^{-\theta_i} \right)^{-\frac{1}{\theta_i}}, \tag{8}$$

and $\theta_i \equiv \sigma_i - 1$ is the trade elasticity. We also define

$$P_n \equiv \prod_{i=1}^{I} P_{in}^{\beta_{in}}. \tag{9}$$

Applying Shephard's Lemma, the value of industry-i exports from n' to n is

$$M_{in'n} = \frac{\left(\tau_{in'n} p_{in'}\right)^{-\theta_i}}{\sum_{n'=1}^{N} \left(\tau_{in'n} p_{in'}\right)^{-\theta_i}} \beta_{in} \left[P_n C_n + \sum_{i=1}^{I} \left(1 - \mu_{in}\right) p_{in} Q_{in} \right], \tag{10}$$

where $\tau_{in'n} \equiv \omega_{in'n}^{-1/\theta_i} d_{in'n}$. We will refer to $\tau_{in'n}$ as the sector-i "trade wedge" which applies to imports of country n from n'. As the model illustrates, we should not think of this wedge as representing trade costs only: $\tau_{in'n}$ encompasses a "preference component", $\omega_{in'n}$, as well as a "trade-cost component", $d_{in'n}$. Our calibration below will not allow us to identify these components separately. Instead, we will obtain only the overall value of the wedge, equalling the ad-valorem tax equivalent of all factors which may impede sectoral trade between country pairs.

From (10) and (3), we can obtain market-clearing conditions

$$r_n K_n + w_n L_n = f_n K_n^{\alpha_n} H_n^{1-\alpha_n} =$$

$$= \sum_{i=1}^{I} \mu_{in} \sum_{n'=1}^{N} v_{inn'} \beta_{in'} \left[f_{n'} K_{n'}^{\alpha} H_{n'}^{1-\alpha} + T_{n'} + \sum_{i=1}^{I} \left(1 - \mu_{in'}\right) p_{in'} Q_{in'} \right], \tag{11}$$

$$p_{in} Q_{in} = \sum_{n'=1}^{N} v_{inn'} \beta_{in'} \left[f_{n'} K_{n'}^{\alpha_{n'}} H_{n'}^{1-\alpha_{n'}} + T_{n'} + \sum_{i=1}^{I} \left(1 - \mu_{in'}\right) p_{in'} Q_{in'} \right], \tag{12}$$

where $v_{inn'} \equiv \left(\tau_{inn'} p_{in}\right)^{-\theta_i} / \sum_{n''=1}^{N} \left(\tau_{in''n'} p_{in''}\right)^{-\theta_i}$. Equations (7) and (8) yield

$$p_{in} = \frac{1}{Z_{in}} f_n^{\mu_{in}} \left\{ \prod_{i=1}^{I} \left[\sum_{n'=1}^{N} \left(\tau_{in'n} p_{in'}\right)^{-\theta_i} \right]^{-\frac{\beta_{in}}{\theta_i}} \right\}^{1-\mu_{in}}. \tag{13}$$

For given model parameters, there is a unique (up to a normalisation) vector of equilibrium factor costs, $\{f_n\}_n$, which satisfies equations (11), (12) and (13).

Finally, we can express the real GDP of country n as

$$Y_n \equiv \frac{f_n K_n^{\alpha_n} H_n^{1-\alpha_n}}{P_n} \equiv A_n K_n^{\alpha_n} H_n^{1-\alpha_n}. \tag{14}$$

$A_n \equiv f_n/P_n$ is the "measured TFP" of country n. In open economies, A_n depends on the factor cost of country n relative to its consumer price level $-$ and thus, indirectly, on the factor endowments, technologies and preferences of all countries, modulated by trade wedges and trade elasticities.[6]

2.3 A "Gravity" Analysis of Bilateral Trade Imbalances

2.3.1 Gravity Representation of Bilateral Trade Imbalances

In order to motivate our quantitative exercise, it is convenient to re-write the expression for bilateral trade flows in equation (10) in "gravity form":

$$M_{in'n} = \left(\frac{\tau_{in'n}}{O_{in'} P_{in}} \right)^{-\theta_i} \frac{q_{in'} \beta_{in}}{\beta_i} \frac{p_{n'} Q_{n'} \left(p_n Q_n + T_n \right)}{\sum_n p_n Q_n}, \tag{15}$$

where $p_n Q_n \equiv \sum_i p_{in} Q_{in}$;$\beta_i \equiv \frac{\sum_n p_{in} Q_{in}}{\sum_n p_n Q_n}$; $q_{in'} \equiv \frac{p_{in'} Q_{in'}}{p_n Q_n}$; and

$$O_{in'} \equiv \left[\sum_n \left(\frac{\tau_{in'n}}{P_{in}} \right)^{-\theta_i} \frac{\beta_{in}}{\beta_i} \frac{\left(p_n Q_n + T_n \right)}{\sum_n p_n Q_n} \right]^{-\frac{1}{\theta_i}} \tag{16}$$

is the outward "multilateral resistance term" of country n'.[7] Thus, the bilateral trade balance between countries n and n' can be written as

$$M_{n'n} - M_{nn'} = \frac{p_{n'} Q_{n'} \left(p_n Q_n + T_n \right)}{\sum_n p_n Q_n} \sum_{i=1}^{I} \left(\frac{\tau_{in'n}}{O_{in'} P_{in}} \right)^{-\theta_i} \frac{q_{in'} \beta_{in}}{\beta_i} +$$

$$- \frac{p_n Q_n \left(p_{n'} Q_{n'} + T_{n'} \right)}{\sum_n p_n Q_n} \sum_{i=1}^{I} \left(\frac{\tau_{inn'}}{O_{in} P_{in'}} \right)^{-\theta_i} \frac{q_{in} \beta_{in'}}{\beta_i}, \tag{17}$$

where $M_{n'n} \equiv \sum_i M_{in'n}$.[8]

2.3.2 The Role of Aggregate Trade Imbalances

Suppose we are in a world in which all countries' trade is balanced in the aggregate: $T_n = 0$ for all n. In this case, the variation in bilateral trade imbalances is driven exclusively by trade wedges and the cross-country differences in technologies and preferences that contribute, along with trade wedges, to differences in q_{in} and β_{in}.

[6] See Feenstra et al. (2009, 2015), and Cuñat and Zymek (2017).

[7] See Anderson and van Wincoop (2003). P_{in} is the inward "multilateral resistance term" of country n.

[8] Equation (17) corresponds to equation (6) in Davis and Weinstein (2002) $-$ up to the terms in round brackets containing the sectoral trade wedges and multilateral resistance terms. In taking this equation to the data, Davis and Weinstein (2002) control for trade barriers by means of standard "gravity" proxies for trade costs, but they omit theory-consistent multilateral resistances.

In comparison with equation (17), the expression for bilateral trade imbalances is reduced to

$$M_{n'n} - M_{nn'} = \frac{p_{n'}Q_{n'}p_nQ_n}{\sum_n p_nQ_n} \left[\sum_{i=1}^{I} \left(\frac{\tau_{in'n}}{O_{in'}P_{in}} \right)^{-\theta_i} \frac{q_{in'}\beta_{in}}{\beta_i} + \right.$$

$$\left. - \sum_{i=1}^{I} \left(\frac{\tau_{inn'}}{O_{in}P_{in'}} \right)^{-\theta_i} \frac{q_{in}\beta_{in'}}{\beta_i} \right], \tag{18}$$

and displays one fewer source of variation.[9]

2.3.3 The Role of Asymmetric Trade Wedges

Suppose now all aggregate trade is balanced as in 2.3.2, but also all trade wedges are symmetric within each country pair: $\tau_{in'n} = \tau_{inn'}$ for all i, n, n'. In comparison with equation (18), we again have one fewer source of variation:

$$M_{n'n} - M_{nn'} = \frac{p_{n'}Q_{n'}p_nQ_n}{\sum_n p_nQ_n} \sum_{i=1}^{I} \frac{\tau_{in'n}^{-\theta_i}}{\beta_i} \left[\frac{q_{in'}\beta_{in}}{(O_{in'}P_{in})^{-\theta_i}} - \frac{q_{in}\beta_{in'}}{(O_{in}P_{in'})^{-\theta_i}} \right]. \tag{19}$$

The variation in bilateral trade imbalances is driven now by cross-country differences in industrial production and expenditure patterns ("triangular trade"). These are determined by cross-country differences in technologies and preferences, weighted by the symmetric sectoral trade wedges.

2.3.4 The Role of Triangular Trade

Finally, suppose aggregate trade is balanced and trade wedges are pairwise symmetric as in 2.3.3 and, in addition, parameters are such that $\beta_{in} = \beta_i$ and $q_{in} = q_i$ for all i, n, n'. There now remain no sources of variation for bilateral trade imbalances: $O_{in} = P_{in}$ for all i, n and thus

$$M_{n'n} - M_{nn'} = 0. \tag{20}$$

3 Data and Calibration

3.1 Data

Our analysis relies on data from two sources: the Penn World Tables (PWT; Feenstra et al., 2015), and the World Input Output Database (WIOD; Timmer et al., 2015).

[9]Equation (18) highlights the influence of market size on bilateral trade imbalances, reflected in the product of the gross-output levels of countries n and n'. Correcting $M_{n'n} - M_{nn'}$ by a measure of only the market size of country n(such as p_nQ_n or P_nY_n) makes the resulting ratio directly depend on the relative size of the partner market.

For all data taken from these sources, we calculate the simple average of the values from the 5 most recent years available, 2010-2014. We do this so as to average out short-run fluctuations in the values of trade balances, incomes and expenditure shares.

Data on countries' real incomes and factor endowments, $\{Y_n, K_n, H_n\}_n$, as well as information on their labour shares, $\{1-\alpha_n\}_n$, is taken directly from PWT 9.0. The dollar value of country-n spending on country-n' output in sector i, $\{M_{in'n}\}_{i,n',n}$, the share of total country-n spending on sector-i, $\{\beta_{in}\}_{i,n}$, as well as the share of country-n spending on intermediates in sector i, $\{\mu_{in}\}_{i,n}$, can be calculated from the values of intermediate and final spending at the country-pair, sector-pair level in the 2016 release of WIOD. WIOD also provides us with consistent values of countries' aggregate trade deficits, $\{T_n\}_n$.

The 2016 release of WIOD consists of annual global input-output tables covering 43 countries (and the "Rest of the World") and 56 sectors. Out of the 43 countries, three have populations of less than 1 million (Cyprus, Luxembourg and Malta), and we merge these with the "Rest of the World" totals to focus on larger and more diversified economies. Out of the 56 sectors, 33 covers services at the 2-digit level of ISIC (Rev. 4). Since a number of these are characterised by little cross-border trade, we aggregate them into 14 broader service-sector categories at the 1-digit level of ISIC (Rev. 4). Our final data set thus covers 40 countries (and the "Rest of the World") and 37 sectors. Tables A1 and A2 in the Appendix give an overview of our aggregation of regions and sectors relative to the original WIOD data.

[Insert Table 1 here]

Our sample contains $(41 \times 40/2 =)$ 820 distinct bilateral trade balances. Table 1 presents summary statistics for these, expressed as a percentage of country-pair GDP. As would be expected, the median value is (approximately) equal to zero. However, there is significant variation in bilateral balances, with more than 20% of observations larger than .12% of country-pair GDP in absolute value.

3.2 Calibration Procedure

The key preference and technology parameters − apart from the trade elasticity −, $\{\alpha_n, \beta_{ni}, \mu_{in}\}_{i,n}$, and the given factor endowments and trade balances, $\{K_n, H_n, T_n\}_n$, can be calibrated in a straightforward manner based on the data described in the previous subsection, as shown in Table 2. For the time being, we set the trade elasticity, $\{\theta_i\}_i$, across all sectors equal to 4, in line with estimates by Simonovska and Waugh (2014) which point to 4 as a reasonable estimate of the aggregate trade elasticity.[10]

[10]The next revision of this paper will feature a calibration which allows for reasonable variation of the trade elasticity across sectors.

We now choose values for $\{\tau_{in'n}\}_{i,n',n}$ and $\{Z_{in}\}_{i,n}$ which allow our model to match observed sector-level bilateral trade values perfectly, proceeding in three steps:

1. If $M_{in'n} = 0$, and $p_{in'}Q_{in'} = 0$, we set $Z_{in'} = 0$.

2. If $M_{in'n} = 0$, and $p_{in'}Q_{in'} > 0$, we set $\tau_{in'n} \to \infty$.

3. If $M_{in'n} > 0$, we write equation (10) as

$$\ln \frac{M_{in'n}}{M_{in^*n}} = S_{in'} - S_{in^*} + e_{in'n}, \tag{21}$$

   where S_{in} is a term which varies across i and n only; $e_{in'n}$ is a sector-country-pair "residual"; and we choose the U.S. as the reference country ($n^* = USA$).[11] We now estimate (21) by OLS, treating S_{in} as a sector-i, country-n fixed effect, and $e_{in'n}$ as a mean-zero residual. We then impose

$$\exp\left(\hat{S}_{in'} - \hat{S}_{in^*}\right) = \left(\frac{Z_{in^*}}{Z_{in'}} \frac{f_{n'}^{\mu_{in'}} P_{n'}^{1-\mu_{in'}}}{f_{n^*}^{\mu_{in^*}} P_{n^*}^{1-\mu_{in^*}}}\right)^{-\theta_i}, \tag{22}$$

$$\exp\left(\hat{e}_{in'n}\right) = \left(\frac{\tau_{in'n}}{\tau_{in^*n}}\right)^{-\theta_i}, \tag{23}$$

   following the approach described in Eaton and Kortum (2002).[12]

Restriction (22) allows us to determine Z_{in}/Z_{in^*} for all $i, n \neq n^*$. Restriction (23) allows us to determine $\tau_{in'n}/\tau_{in^*n}$ for all $i, n' \neq n^*, n$. The latter restriction also implies that our calibration minimises the role of trade wedges in explaining the value of international trade flows, using them only to capture the residual portion which cannot be explained with country-sector variation in unit costs.[13]

Restrictions (22) and (23) are insufficient to also pin down countries' import frictions from the reference country, $\{\tau_{in^*n}\}_n$, and the reference's country's sectoral productivities, $\{Z_{in^*}\}_i$. However, from (7)-(9) and (14),

$$A_n = \frac{f_n}{\prod_{i=1}^{I} \left[\sum_{n'=1}^{N} \left(\frac{\tau_{in'n} f_{n'}}{Z_{in'} A_{n'}^{1-\mu_{in'}}}\right)^{-\theta_i}\right]^{-\frac{\beta_{in}}{\theta_i}}}, \tag{24}$$

and using (24) to match countries' measured TFPs as reported in the PWT, $\{Y_n / \left(K_n^{\alpha_n} H_n^{1-\alpha_n}\right)\}_n$, entails another N restrictions on these parameters. After applying these, we can impose a set of convenient normalisations on the remaining $I + (I-1)N$ free parameters.

[11] $M_{iUSAn} > 0$ for all i and n in our final data set.

[12] See Eaton and Kortum (2002), Section 5.1, pp. 1759-1762.

[13] As a robustness check, we also explore the results of an alternative calibration which minimises cross-country variation in sectoral productivities, setting $Z_{in} = Z_{in^*}$ in step 3. See footnote 19.

First, we normalise $\tau_{in^*n^*} = 1$ for all i, and $\tau_{in^*n} = \tau_{n^*n}$ for all $i, n \neq n^*$. This implies that the value of all trade wedges obtained from our calibrations should be interpreted as relative to the reference country's import friction from itself. Second, we normalise $Z_{in^*} = Z_{n^*}^{\sum_i \beta_{in^*}\mu_{in^*}}$ for all i. This implies that all productivities obtained should be interpreted as relative to the reference country's TFP.[14]

3.3 Calibration Output: Comparative Advantage

In order to illustrate that the calibration strategy described in Section 3.2 yields reasonable implications concerning countries' comparative advantages, Figure 3 describes countries' output prices relative to their aggregate price indices for four sectors − mining and quarrying (ISIC 5-9), manufacture of motor vehicles (ISIC 29), financial and insurance activities (ISIC K), and professional, scientific and technical activities (ISIC M). Everything else constant, a lower output price in sector i relative to a country's overall price index should indicate a comparative advantage in sector i.

[Insert Figure 3 here]

As can be seen from the figure, the calibration-implied patterns of comparative advantage align with reasonable priors about relative productivity in these sectors: Norway, Australia and the U.S. are found to have the strongest comparative advantage in mining and quarrying; Germany, Japan and France in car manufacturing; Switzerland, the U.K. and the U.S. in financial services; and the U.S., Germany and Switzerland in other professional services.

This implication of our calibration procedure is reassuring, but should not be surprising: given (21) and (22), the calibration assigns high relative productivity to country n in a given sector i if, holding everything else constant, n exports a lot relative to the U.S. in sector i. Typical indices of "revealed" comparative advantage based on the observed values of trade flows would ascertain countries' relative advantages in a similar manner (see, for example, Balassa, 1965).[15]

[14] It is easy to show that, given these normalisations,

$$Y_{n^*} = \left(\prod_{i=1}^{I} v_{in^*n^*}^{-\frac{\beta_{in^*}}{\theta_i}} \right)^{\frac{1}{\sum_{i=1}^{I} \beta_{in^*}\mu_{in^*}}} Z_{n^*} K_{n^*}^{\alpha_{n^*}} H_{n^*}^{1-\alpha_{n^*}},$$

where $v_{in^*n^*} \equiv M_{in^*n^*} / \sum_n M_{inn^*}$.

[15] Indeed, it is possible to show that a revealed comparative advantage index consistent with our calibration would be

$$\frac{Z_{in}}{Z_{in^*}} = \left[\prod_{n' | M_{inn'} > 0} \left(\frac{M_{inn'}}{M_{in^*n'}} \right)^{\frac{1}{N_{in}}} \right]^{\frac{1}{\theta_i}} \left[\frac{\sum_{i=1}^{I} \mu_{in} \sum_{n''=1}^{N} M_{inn''}}{\left(K_n^{\alpha_n} H_n^{1-\alpha_n}\right)^{\mu_{in}} Y_n^{1-\mu_{in}}} \Big/ \frac{\sum_{i=1}^{I} \mu_{iUS} \sum_{n''=1}^{N} M_{iUSn''}}{\left(K_{n^*}^{\alpha_{n^*}} H_{n^*}^{1-\alpha_{n^*}}\right)^{\mu_{in^*}} Y_{US}^{1-\mu_{in^*}}} \right],$$

where N_{ni} is the number of countries with a strictly positive value of imports from n in sector i.

3.4 Calibration Output: Trade Wedges

Table 2 provides summary statistics for all finite trade friction parameters which can be obtained using the calibration procedure in Section 3.2.[16] The median value is large, implying an ad-valorem tax equivalent of trade wedges equal to 340%. This is consistent with earlier studies which have found that large trade wedges are required to reconcile quantitative models with the value of cross-border transactions.[17]

[Insert Table 2 here]

In the following, we are primarily interested in asymmetries of trade wedges at the country-pair level. To provide an overview of these, we calculate the import-weighted average trade friction of country n from country n' as $\tau_{n'n} \equiv \tau_{in'n} M_{in'n} / \sum_i M_{in'n}$. There are $(41 \times 40/2 =)$ 820 distinct country pairs, and Table 3 reports the absolute value of the log difference in bilateral trade wedges for each of them.

[Insert Table 3 here]

In a world of bilaterally symmetric trade wedges, we would expect the numbers in Table 3 to be small in magnitude. Yet, the median log difference of .400 suggests that for about half of all country pairs, the weighted average import friction is at least 40% higher in one direction than in the other. For 10% of countries, it is more than twice as large in one direction than in the other. It thus appears that sizeable asymmetries in trade wedges at the country-pair level are required to reconcile a standard quantitative trade model with the observed values of sectoral bilateral trade flows.[18]

[Insert Figure 4 here]

By way of illustration, Figure 4 displays the log difference between the U.S. average import wedge from each of its trading partners and the corresponding partner's average import wedge from the U.S. As can be seen from the figure, the U.S. faces lower import wedges from most of its trade partners relative to the wedges which apply to U.S. imports in the partner country. In some cases, these differences are stark:

[16] Note that we cannot determine the value of $\tau_{in'n}$ if $p_{in'} Q_{in'} = 0$.

[17] For example, Anderson and van Wincoop (2004) identify a representative trade barrier equivalent to a 170% ad-valorem tax equivalent from standard gravity models. However, this figure represents an average across only manufacturing sectors in rich countries, while our data encompasses all sectors of the economy and a mix of developed and developing economies.

[18] As a robustness check on our findings, we perform an alternative calibration which sets $Z_{in} = Z_{in^*}$ for all n in step 3 of the procedure described in Section 3.2, but leaves the other steps and normalisations unchanged. The corresponding calibration-implied trade wedges are larger in magnitude and more variable than those found under our baseline calibration. However, the log difference in import-weighted trade wedges between country pairs is highly and significantly correlated with its baseline counterpart at .63, and the sign of the difference is the same for 75% of country pairs.

the calibration implies that import wedges from the U.S. to Japan and Mexico are more than twice as large as import wedges from those countries to the U.S. Figures 5 and 6 show that these numbers are not a mere artefact of our aggregation: across most sectors, Japanese and Mexican import wedges from the U.S. are significantly larger than U.S. import wedges from Japan and Mexico.

[Insert Figures 5 and 6 here]

In order to ascertain whether the asymmetries in trade wedges appear to be systematically related to observable characteristics of country pairs, we regress them on a range of standard "gravity" variables for all pairs (except the 40 pairs involving the Rest of the World). The results are displayed in Table 4. Columns 1-3 successively introduce some commonly used variables in the empirical analysis of bilateral trade flows: the log of population-weighted distance between countries n' and n (see Head and Mayer, 2014); a "contiguous" dummy which takes value 1 if n' and n share a common border, 0 otherwise; a "colonial" dummy which takes value 1 if n' and n share a colonial history, 0 otherwise; a "common currency" dummy which takes value 1 if n' and n share a currency, 0 otherwise; an FTA dummy which takes value 1 if n' and n are parties to a free-trade agreement, 0 otherwise; and an EU dummy which takes value 1 if n' and n are both EU members, 0 otherwise. In addition, the specification in column 4 employs a full set of country fixed effects.

[Insert Table 4 here]

The trade-wedge asymmetries implied by our calibration do not correlate strongly with most of these gravity variables: with two exceptions, the estimated coefficients are small and not robustly statistically significant. The exceptions are the coefficients on the log of distance, and the EU dummy. Geographically separated countries appear to have more asymmetric bilateral wedges on average, with a one percent increase in the distance between country pairs being associated with a .07-.13 percent increase in the difference between bilateral import wedges. EU member countries appear to have more symmetric wedges, EU membership being associated with a 12-22% reduction in the difference between bilateral import wedges on average.

These correlations are suggestive. The positive association of distance with asymmetries in trade wedges may reflect that transport costs become more asymmetric over longer distances − for example, because air transport is more likely to be used as a mode of transportation for long-distance shipments (Harrigan, 2005) but East-West flight times exceed West-East flight times for given routes. The negative association of EU membership with asymmetries could indicate that some asymmetries are due to unilateral non-tariff policy barriers to trade, relating to product standards or public procurement practices, whose scope is more heavily restricted among members of the EU single market. While the correlations in Table 4 cannot provide conclusive evidence in support of either of these explanations, they nevertheless indicate that our calibration-implied trade-wedge asymmetries are likely to reflect a range of different obstacles to "balanced" trade between country pairs.

4 Counterfactuals

4.1 Bilateral Balance Accounting

As shown in Section 2.3, our calibrated quantitative model will attribute observed (variation in) bilateral trade imbalances to a combination of three factors: i) differences in countries' aggregate trade balances, ii) differences in countries' production structure and expenditure patterns, and iii) asymmetric frictions between trade partners. In this section, we will quantify the relative importance of these factors through a number of counterfactuals.

The reason we need to employ counterfactuals in order to account for the contribution of the abovementioned factors to the observed variation in trade balances across country pairs can be gauged from equation (17). While aggregate trade balances and bilateral trade wedges directly affect the balance of trade between countries n' and n, as (17) shows, they also have an indirect effect through their impact on equilibrium factor costs, $\{f_n\}_n$, which – in turn – influence $p_nQ_n/\sum_n p_nQ_n$, $p_{n'}Q_{n'}/\sum_n p_nQ_n$, and $\{q_{in}, q_{in'}, O_{in}, O_{in'}, P_{in}, P_{in'}\}_i$. This also implies that the contribution of any one driver of bilateral imbalances is not easily separable from those of the other two: for example, the impact of balanced trade at the country level ($T_n = 0$ for all n) on trade balances between country pairs may be contingent on whether or not bilateral trade wedges are symmetric.

For expositional clarity, we limit ourselves to three counterfactuals: first, we obtain the variation in bilateral trade balances which would prevail if all countries' overall trade were balanced; second, we obtain the counterfactual variation in bilateral trade balances which would prevail if trade wedges within all country pairs were symmetric; finally, we determine the variation in bilateral trade balances which would occur under *both* country-level balanced trade *and* symmetric frictions within country pairs. Note that, in line with the discussion in Section 2.3, all remaining variation in bilateral trade balances under the third scenario will be due to differences in the production structure and expenditure patterns of countries.[19]

[19]Exploring a counterfactual in which countries have the same production structure and expenditure patterns for given aggregate trade balances and trade wedges is tricky: it would require us to set $\beta_{in} = \beta_i$ for all i, n, and achieve $q_{in} = q_i$ for all i, n in equilibrium. The latter is possible through suitable re-calibration of $\{Z_{in}\}_{i,n}$. However, since countries' sector output shares are equilibrium objects, the appropriate re-calibration of their sectoral productivities would depend on the value of all other model parameters, including $\{T_n\}_n$ and $\{\tau_{in'n}\}_{i,n',n}$ – and therefore differ depending on the benchmark scenario. To sidestep the conceptual difficulties in interpreting such a counterfactual, we treat production/expenditure differences as the "residual" case of our counterfactuals.

The parametrisation of the aggregate-balanced-trade counterfactual is straightforward: we simply set $T_n = 0$ for all n. For the symmetric-friction counterfactual, we replace the calibrated sector-i wedges between country n' and n, and between n and n', from Section 3.2 with their geometric average. In the "combined" counterfactual, we impose both these new parameterisations simultaneously. The results are presented in Table 5.

[Insert Table 5 here]

Counterfactual 1 results in a 10% decline in the standard deviation of bilateral trade balances, suggesting that aggregate trade trade surpluses/deficits play a relatively small role in explaining the observed variation in trade balances between country pairs. By contrast, counterfactual 2 results in a 21% decline in in the standard deviation of bilateral trade balances − more than twice the impact of counterfactual 1. Finally, counterfactual 3 results in a 45% decline in bilateral-balance differences between countries, so the combined effects of balanced aggregate trade and symmetric trade wedges exceed the sum of the individual effects. Therefore, depending on how this interactive effect is allocated between the two counterfactual changes, we find that aggregate trade surpluses/deficits account for 10-24% of the observed variation in bilateral balances, and asymmetric trade wedges for 21-35%.

These numbers are thought-provoking for at least two reasons. First, aggregate trade surpluses/deficits, which are most frequently cited as a reason for bilateral imbalances in the public discourse, actually play a relatively minor role in explaining why the bilateral trade positions of countries differ so much in the data. Instead, most of these differences seem to occur because countries differ in their comparative advantages and expenditure patterns. Second, the reasons for between a fifth and a third of bilateral imbalances are unaccounted for − which causes our exercise to ascribe them to asymmetric frictions. Section 3.4 already showed that our calibration implies large trade-wedge asymmetries within country pairs. Our counterfactuals here suggest that these underpin a significant portion of bilateral imbalances − and that trade patterns between countries would look very different in their absence. In the next section, we provide some indication that the changes in trade patterns which would result from counterfactually symmetric frictions could come hand-in-hand with substantial changes in countries' welfare.

4.2 Welfare Analysis

How big is the potential impact of the large asymmetries in trade wedges implied by our calibration on countries' levels of welfare? In this section, we provide a tentative answer to this question using the framework outlined in Section 2.[20]

As highlighted in Sections 2 and 3, the set of parameters we have referred to as "trade wedges" throughout the paper, $\{\tau_{in'n}\}_{i,n',n}$, capture the ad-valorem tax equivalent of all impediments to trade between any two countries in a given sector − which, in addition to shipping costs and policy barriers to trade, may include specific differences in tastes for each other's goods. Since we cannot distinguish physical barriers to trade from preferences in the data, our welfare analysis must rely on a stronger assumption about the nature of trade wedges than we have made so far:

$$\tau_{in'n} = d_{in'n} \tag{25}$$

for all i, n', n. Equation (25) states that, in the following, we will treat our trade-wedge parameters as representing predominantly transportation and policy barriers to trade. As in Section 4.1, we will replace calibrated wedges in sector i between country n' and n, and between n and n', with their geometric average (corresponding to counterfactual 2). The resulting changes in welfare can be interpreted as an upper-bound on the welfare implications of moving to a world with symmetrically "averaged" shipping costs and policy barriers to trade.

Since our static model does not allow us to analyse changes in steady-state capital stocks and aggregate net exports in response to parameter changes, we hold $\{K_n\}_n$ and $\{T_n\}_n$ constant in our welfare analysis. This implies that the numbers below should be interpreted as indicative of the short-run effect of a sudden move to symmetric frictions, before the adjustment of $\{K_n\}_n$ and $\{T_n\}_n$ towards a new steady state has taken place. This static effect of symmetric frictions on countries' welfare occurs entirely through changes in the equilibrium values of $\{f_n, P_n\}_n$ in response to the change in trade wedges implied by our counterfactual.

[Insert Figure 7 here]

Figure 7 represents an overview of the welfare changes implied by our trade-cost counterfactual. Unsurprisingly, the welfare effects are generally larger in magnitude for smaller economies, and there are both overall winners and losers. The latter follows because our counterfactual implies higher overall import costs for some countries, but lower overall import costs for others. Perhaps more surprising is that the welfare effects are sizeable: even for large economies such as Germany and the U.K., the move to symmetric trade frictions implies changes in real consumption amounting to -.5% and 1.0%, respectively. Moreover, countries which we found to face lower inward frictions than outward frictions across the board − such as the U.S. −see their welfare reduced under symmetric barriers, while countries which face higher inward

[20] A more thorough answer would require a dynamic model, with endogenous trade balances and capital stocks. We will provide it in the next revision of this paper.

frictions than outward frictions − such as Japan and Mexico − are beneficiaries of our counterfactual change in trade frictions. This is intuitive: given the nature of our counterfactual, the first-order effect of symmetric trade barriers on U.S. welfare comes in the form of a higher price of consumer goods, as a result of higher ad-valorem import costs. The reverse is true for Japan and Mexico.

[Insert Figure 8 here]

Figure 8 showcases the effect of our counterfactual on U.S. bilateral balances. Since we hold T_{USA} constant, the change in trade frictions merely re-distributes the overall U.S. trade deficit across its trade partners. This results in large increase in the U.S. deficit with the Rest of the World, but a reduction in U.S. deficits with most of its other trade partners. Most notably, the U.S. deficits with China, Mexico, Canada and Japan are all reduced by more than 50%. Our analysis thus cautions against an association of these deficits with negative welfare consequences for the U.S. Taking the findings of our calibration and counterfactuals at face value, they may reflect asymmetries of trade barriers which favour U.S. consumers − and the removal of which would result in a (moderate) *reduction* in real U.S. consumption possibilities.

5 Conclusion

We use a standard quantitative trade model to account for the sectoral trade and production patterns of 40 economies (and the rest of the world) as reported in the WIOD. The model is calibrated to match observed aggregate trade balances, sectoral expenditure and production shares, and sector-level bilateral trade flows. Through a sequence of counterfactuals, we illustrate the relative importance for the observed variation in bilateral trade balances of i) cross-country differences in aggregate trade balances, ii) cross-country differences in expenditure and production patterns, and iii) asymmetric trade wedges, capturing a range of possible (pairwise asymmetric) impediments to trade. We find that most of the variation can be attributed to international differences in expenditure and production patterns. However, a sizeable share (21-35%) of that variation cannot be explained without asymmetric trade wedges. If we interpret these wedges as reflecting trade costs, the removal of the asymmetries implied by our calibration would have a significant effect on international trade patterns and welfare.

Two aspects of our findings are noteworthy. First, bilateral trade imbalances regularly fuel political controversies between observers who regard them as a symptom of unfair trade practices (which our calibration would capture as asymmetric trade wedges) and observers who see them as a mere reflection of countries' macroeconomic conditions (which our calibration would capture as differences in aggregate trade balances). Our results suggest that neither of these views can account for the bulk of observed variation in bilateral trade balances. Instead, more than half of it appears to be due to the well-documented differences in countries' expenditures and industrial structures.

Second, the significant role of asymmetric trade wedges raises the question as to what exactly these wedges represent. Taking our model at face value, our calibrated wedges are the combined ad-valorem tax equivalent of trade-impeding differences in preferences, transport costs and policy-induced barriers to trade. Further research into the determinants of trade patterns could help us differentiate between the first two components and the third − and thus to determine whether any asymmetries are incidental, or potentially nefarious. Since our calibrated wedges are obtained as a residual, another possibility is that they reflect measurement error in the data, or a shortcoming of standard quantitative trade models in explaining the observed values of trade flows. Hence, future research which reduces the reliance of calibrated trade models on large and variable trade wedges would also allow us to provide a more complete account of the factors contributing to (differences in) bilateral trade imbalances.

$100 \times \sum_i (M_{inn'} - M_{in'n}) / (P_n Y_n + P_{n'} Y_{n'})$					
# obs.	mean	st. dev.	10th pctl.	median	90th pctl.
820	.000	.185	-.122	.000	.127

Table 1: Bilateral trade imbalances: 40 countries and Rest of the World

$\tau_{in'n}$					
# obs.	mean	st. dev.	10th pctl.	median	90th pctl.
60,273	5.4	4.3	2.0	4.4	9.6

Table 2: Calibration-implied trade-wedge parameters

$\ln \tau_{n'n} - \ln \tau_{nn'}$					
# obs.	mean	st. dev.	10th pctl.	median	90th pctl.
820	.486	.384	.073	.400	1.024

Table 3: Calibration-implied asymmetries in trade wedges

Dep. var.: $\ln \tau_{n'n} - \ln \tau_{nn'}$				
	(1)	(2)	(3)	(4)
log dist.	.128*** (.013)	.111***(.013)	.102***(.021)	.072** (.030)
contiguous	.062 (.043)	.071 (.045)	.063 (.047)	.006 (.048)
com. lang.		-.043 (.069)	-.057 (070)	-.026 (.068)
colonial		-.010 (.068)	-.009 (.065)	.068 (.046)
com. curr.		-.187*** (.023)	-.141*** (.026)	.054 (.035)
FTA			.073* (.045)	.044 (.061)
EU			-.123*** (.037)	-.222*** (.062)
country F.E.	No	No	No	Yes
# obs.	780	780	780	780
R^2	.12	.15	.16	.49

* $p < .10$; ** $p < .05$; ***$p < .01$;

standard errors in parentheses

Table 4: Asymmetries in trade wedges and “gravity” variables

$100 \times (M_{nn'} - M_{n'n}) / (P_n Y_n + P_{n'} Y_{n'})$						
		# obs.	st. dev.	10th pctl.	median	90th pctl.
Data		820	.185	-.122	.000	.127
Counterfactual 1:	$T_n^{new} = 0 \; \forall \; n$	820	.166	-.125	.000	.110
Counterfactual 2:	$\tau_{in'n}^{new} = \tau_{in'n}^{\frac{1}{2}} \tau_{inn'}^{\frac{1}{2}}$ $\forall \; i, n', n$	820	.146	-.070	.000	.084
Counterfactual 3:	$\tau_{in'n}^{new} = \tau_{in'n}^{\frac{1}{2}} \tau_{inn'}^{\frac{1}{2}}$ & $T_n^{new} = 0 \; \forall \; i, n', n$	820	.102	-.052	.001	0.51

Table 5: Bilateral balance accounting

WIOD (2016)		Final data	
Country	Code	Country	Code
Australia	AUS	Australia	AUS
Austria	AUT	Austria	AUT
Belgium	BEL	Belgium	BEL
Brazil	BRA	Brazil	BRA
Bulgaria	BGR	Bulgaria	BGR
Canada	CAN	Canada	CAN
China	CHN	China	CHN
Croatia	HRV	Croatia	HRV
Cyprus	CYP	Rest of the World	RoW
Czech Republic	CZE	Czech Republic	CZE
Denmark	DNK	Denmark	DNK
Estonia	EST	Estonia	EST
Finland	FIN	Finland	FIN
France	FRA	France	FRA
Germany	DEU	Germany	DEU
Greece	GRC	Greece	GRC
Hungary	HUN	Hungary	HUN
India	IND	India	IND
Indonesia	IDN	Indonesia	IDN
Ireland	IRL	Ireland	IRL
Italy	ITA	Italy	ITA
Japan	JPN	Japan	JPN
Korea	KOR	Korea	KOR
Latvia	LVA	Latvia	LVA
Lithuania	LTU	Lithuania	LTU
Luxembourg	LUX	Rest of the World	RoW
Malta	MLT	Rest of the World	RoW
Mexico	MEX	Mexico	MEX
Netherlands	NLD	Netherlands	NLD
Norway	NOR	Norway	NOR
Poland	POL	Poland	POL
Portugal	PRT	Portugal	PRT
Rest of the World	RoW	Rest of the World	RoW
Romania	ROU	Romania	ROU
Russia	RUS	Russia	RUS
Slovakia	SVK	Slovakia	SVK
Slovenia	SVN	Slovenia	SVN
Spain	ESP	Spain	ESP
Sweden	SWE	Sweden	SWE
Switzerland	CHE	Switzerland	CHE
Taiwan	TWN	Taiwan	TWN
Turkey	TUR	Turkey	TUR
U.K.	GBR	U.K.	GBR
U.S.	USA	U.S.	USA

Table A1: Country sample

WIOD (2016)		Final data
Sector	ISIC 2-dg.	ISIC 1/2-dg.
Crop and animal production...	1	1
Forestry and logging	2	2
Fishing and aquaculture	3	3
Mining and quarrying	5-9	5-9
Manufacture of food products,...	10-12	10-12
Manufacture of textiles,...	13-15	13-15
Manufacture of wood and...	16	16
Manufacture of paper and...	17	17
Printing and reproduction...	18	18
Manufacture of coke and...	19	19
Manufacture of chemicals...	20	20
Manufacture of basic pharma...	21	21
Manufacture of rubber and...	22	22
Manufacture of other non-metal...	23	23
Manufacture of basic metals	24	24
Manufacture of fabricated metal...	25	25
Manufacture of computer,...	26	26
Manufacture of electrical equip...	27	27
Manufacture of machinery and...	28	28
Manufacture of motor vehicles,...	29	29
Manufacture of other transport...	30	30
Manufacture of furniture; other...	31-32	31-32
Repair and installation...	33	33
Electricity, gas, steam and...	35	D
Water collection, treatment...	36	E
Sewerage; waste collection,...	37-39	E
Construction	41-43	F
Wholesale and retail...	45	G
Wholesale trade, except...	46	G
Retail trade, except of...	47	G
Land transport and...	49	H
Water transport	50	H
Air transport	51	H
Warehousing and support...	52	H
Postal and courier activities	53	H
Accommodation and food...	55-56	I
Publishing activities	58	J
Motion picture, video and...	59-60	J
Telecommunications	61	J
Computer programming,...	62-63	J
Financial service activities,...	64	K
Insurance, reinsurance and...	65	K
Activities auxiliary to financial...	66	K
Real estate activities	68	X
Legal and accounting activities;...	69-70	M
Architectural and engineering...	71	M
Scientific research and...	72	M
Advertising and market research	73	M
Other professional, scientific...	74-75	M
Administrative and support...	77-82	N
Public administration and...	84	O
Education	85	P
Human health and social work...	86-88	Q
Other service activities	90-96	X
Activities of households...	97-98	X
Activities of extraterritorial...	99	X

Table A2: Sector sample

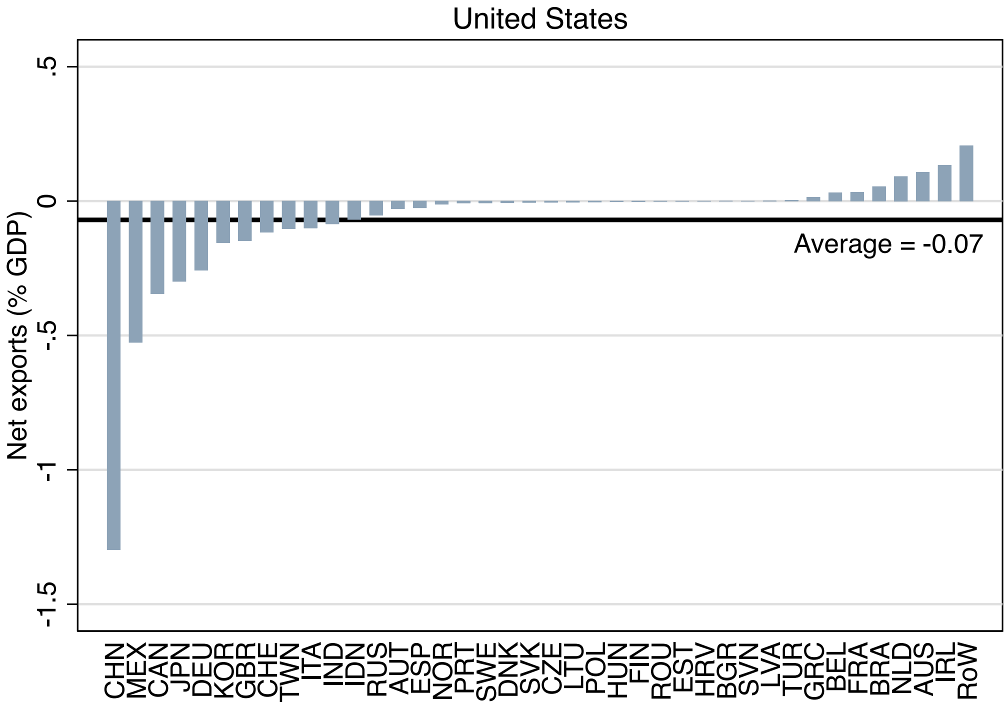

Figure 1: U.S. bilateral trade balances, 2010-2014

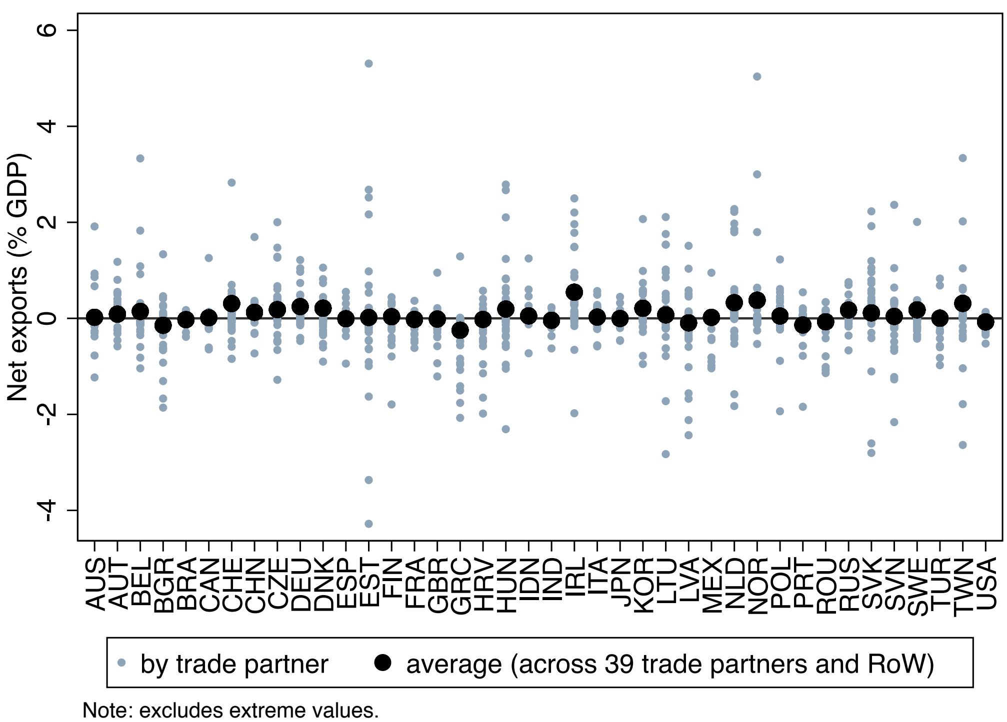

Figure 2: Bilateral trade balances for 40 economies, 2010-2014

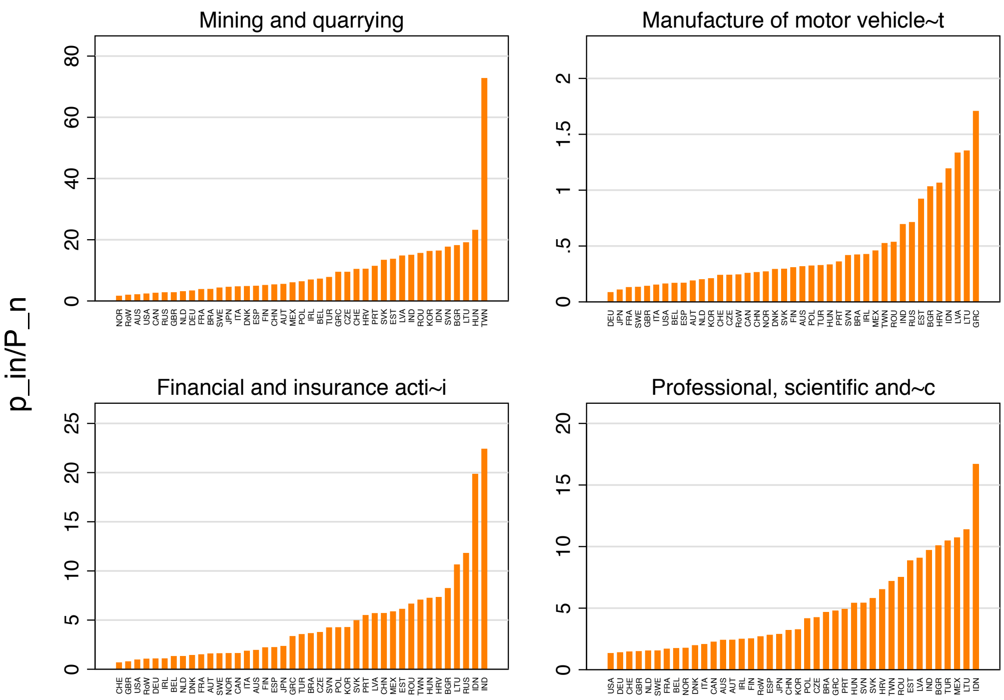

Figure 3: Patterns of comparative advantages in four sectors

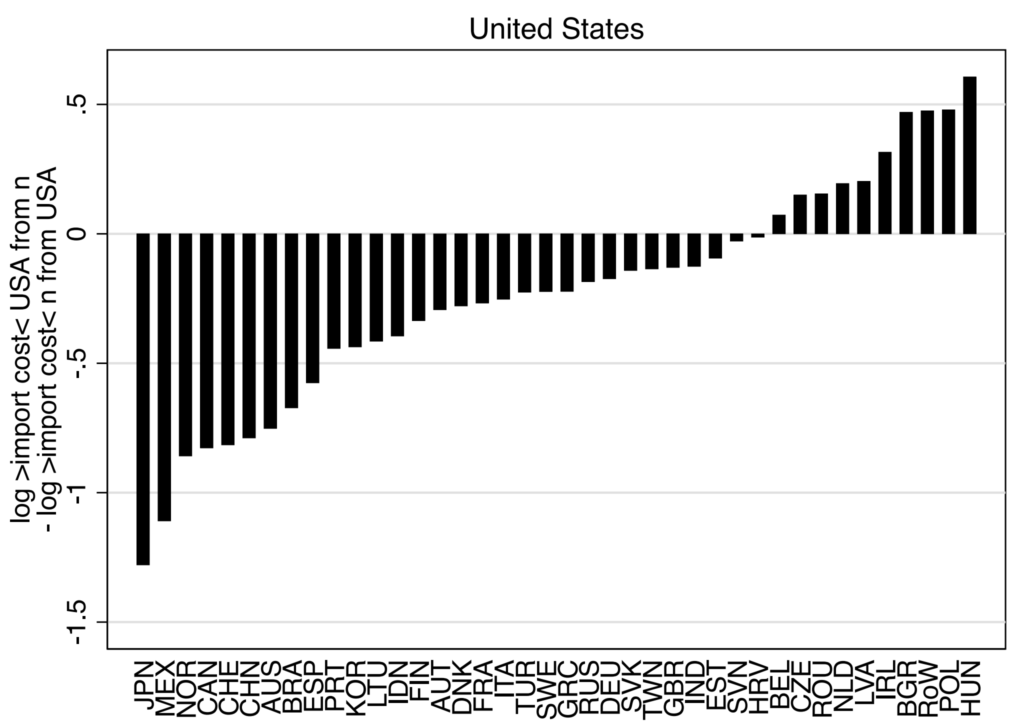

Figure 4: Asymmetries in trade wedges between U.S. and 40 trade partners

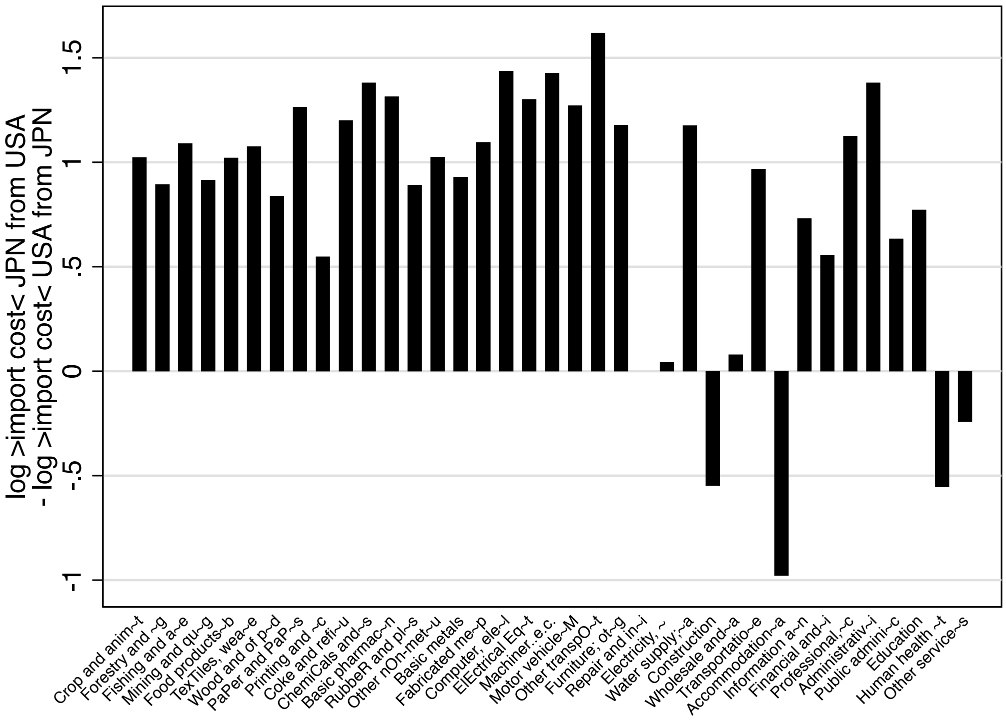

Figure 3: Asymmetries in trade wedges between Japan and U.S. across sectors

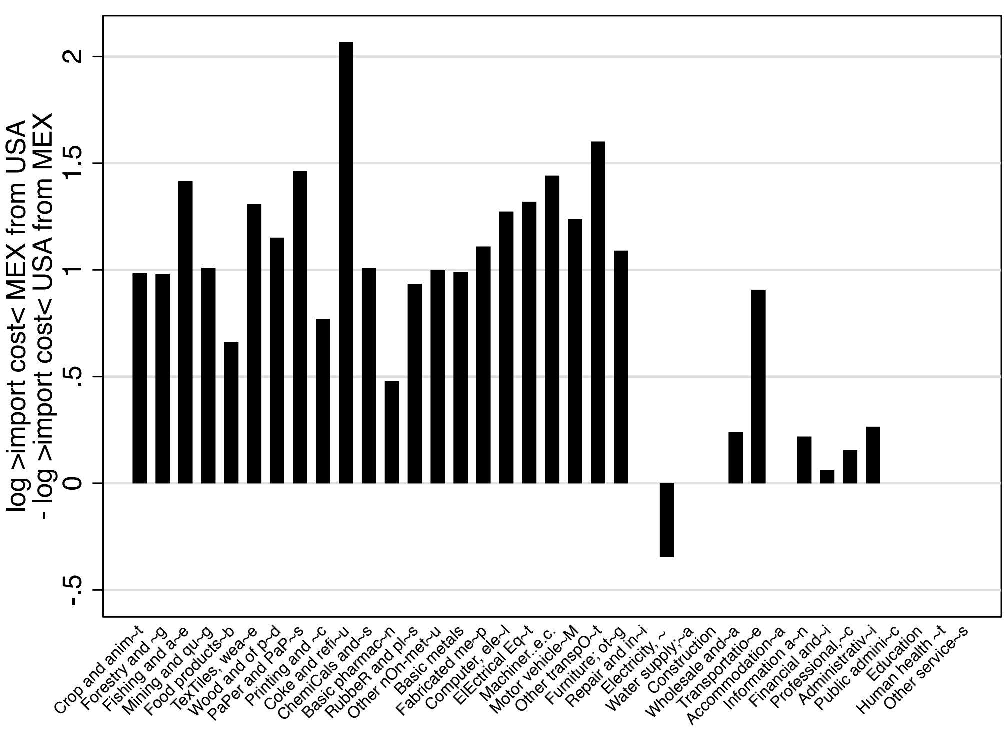

Figure 4: Asymmetries in trade wedges between Mexico and U.S. across sectors

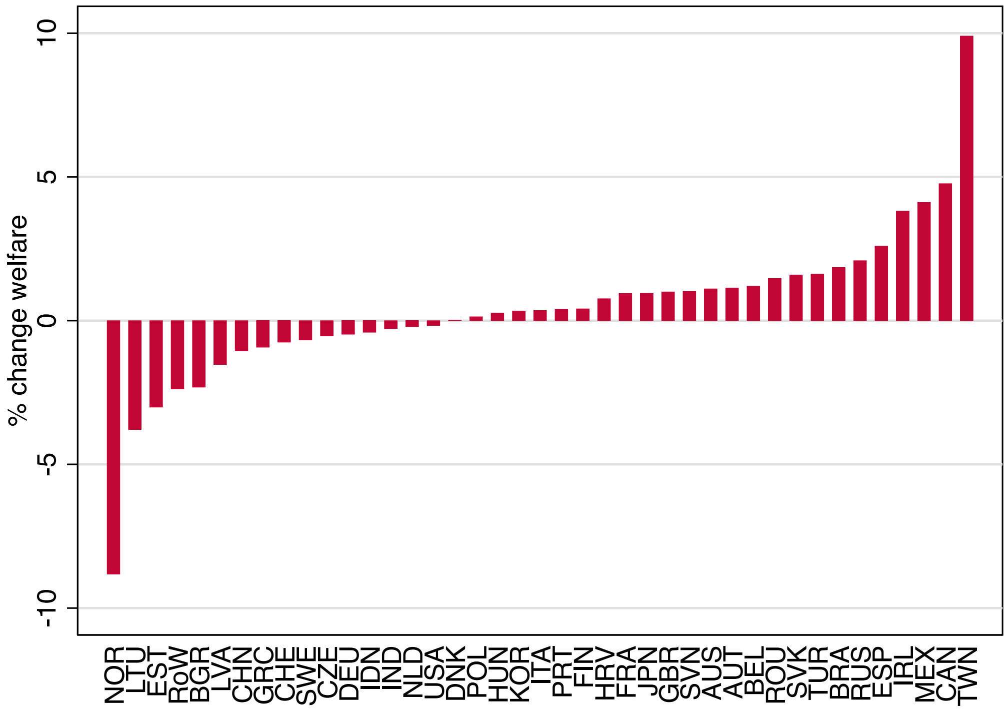

Figure 7: Welfare impact of pairwise symmetric trade frictions across sectors

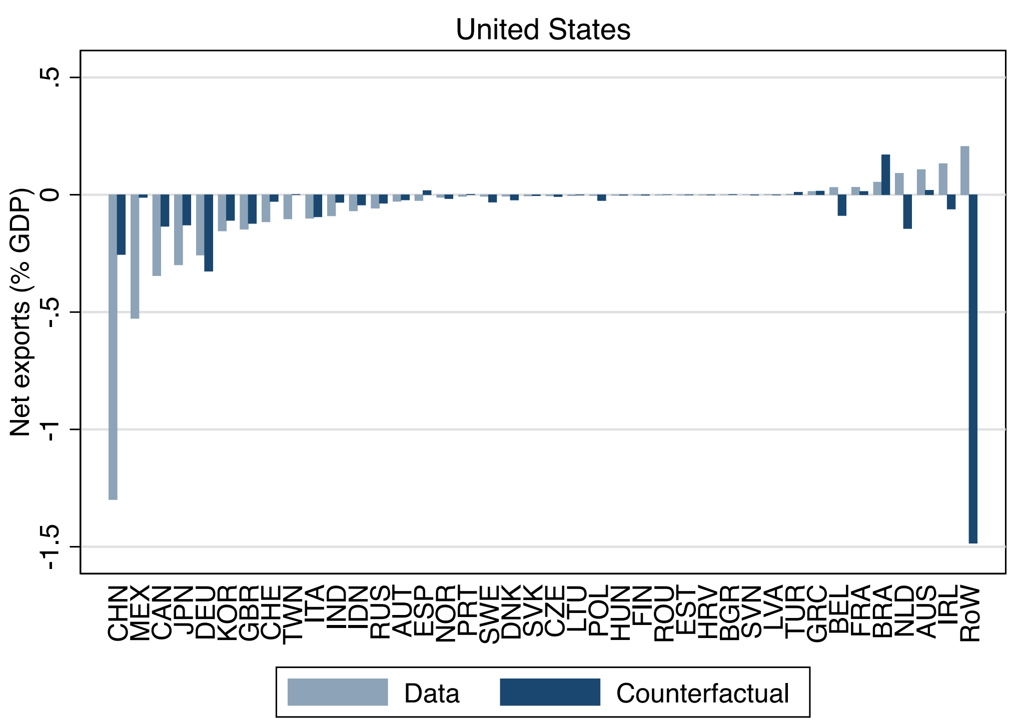

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Figure 8: U.S. bilateral trade balances with pairwise symmetric trade frictions across sectors

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