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From Theory to Policy with Gravitas: A Solution to the Mystery of the Excess Trade Balances

Gabriel Felbermayr
Kiel Institute & Kiel University

Yoto V. Yotov
Drexel University

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JEL classification: F1; F13; F14

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Gabriel Felbermayr
Kiel University
IfW Kiel

Yoto V. Yotov†
Drexel University
ifo Institute

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Bilateral trade balances often play an important role in the international trade policy debate. Academic economists understand that they are misleading indicators of competitiveness and of the gains from trade. However, they also recognize their political relevance, calling for accurate statistical measurement and for more scholarly work. Disturbingly, Davis and Weinstein (2002) argue that the canonical gravity model of trade fails when confronted with bilateral trade balances data, dubbing this "The Mystery of the Excess Trade Balances". Capitalizing on the latest developments in the theoretical and empirical gravity literature, we demonstrate that the workhorse international trade model actually performs well in explaining bilateral trade balances. Moreover, in our data, only 11 to 13% of the variance in bilateral balances is due to asymmetric bilateral trade costs, belying beliefs that bilateral imbalances are driven by 'unfair' manipulation of terms-of-trade. We also perform several general equilibrium experiments within the same structural gravity framework to show that free trade agreements tend to exacerbate bilateral imbalances and that macroeconomic rebalancing leads to adjustment with all trade partners.

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*The title was inspired by the seminal paper, "Gravity with Gravitas: A Solution to the Border Puzzle", by James E. Anderson and Eric van Wincoop, 2003. In the spirit of that paper, we show that proper accounting for multilateral resistances is also important for predicting bilateral trade balances successfully. In addition, we account for several more recent developments in the structural gravity literature.

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"When net exports are negative, that is, when a country runs a trade deficit by importing more than it exports, this subtracts from growth."

(Navarro and Ross, 2016)

"We use the canonical 'gravity model' of bilateral trade to form predictions about bilateral trade balances ... Our results paint a dismal picture. The central explanations that economists provide to explain bilateral imbalances fail miserably ... These failures require that we move beyond the simple gravity framework."

(Davis and Weinstein, 2002)

1 Introduction

Trade balances play a very important role in current trade policy negotiations and popular discussions, and always have.[1] Bilateral trade balances, in particular, seem to be widely taken as an indicator of "fairness" in trade relations. Frequent tweets of U.S. President Donald Trump very clearly point into this direction. Most economists understand that bilateral trade balances are of no relevance for whether and to what extent a country benefits from international trade. Therefore, they should not matter for the design of a welfare-maximizing trade policy. However, academic economists also recognize the important role that trade balances play in actual trade policy negotiations, and they call for more rigorous scholarly work in this area; *"Because the bilateral trade deficit has real consequences on trade policies, we should definitely solve the technical problem of measuring it accurately."* (Feenstra et al., 1999).[2] Yet, as recently noted by Paul Krugman in his New York Times column, *"[s]omewhat surprisingly, there's not a lot of economic literature on the causes of*

[1]The opening quote of our paper is from an op-ed on Trump's economic plan, written by Commerce Secretary Wilbur Ross and trade adviser Peter Navarro in September 2016. Similarly, Davis and Weinstein (2002) note that "[b]ilateral trade deficits are a perennial policy issue" (p. 170), and motivate their work on trade balances with a quote from the former Deputy Assistant U.S. Trade Representative for Japan and China, Merit Janow that during the first George Bush administration, "High deficits coupled with the continuing allegations from U.S. business interests about the closed nature of the Japanese market were resulting in serious domestic pressures for improved access to the Japanese market" (Janow, 1994, p.55).

[2]Bilateral balances are measured with substantial error. This is particularly true for services trade and primary income. Braml and Felbermayr (forthcoming) show that even the sign of the US-EU current account balance is essentially unknown. In this paper we focus on goods trade which is more accurately measured in international statistics.

bilateral trade imbalances." (May 31, 2017). In fact, the only academic paper that Krugman cites in his article is Davis and Weinstein (2002).

Quite disturbingly, and as captured by the second opening quote, Davis and Weinstein (2002) find that the most successful empirical trade model, i.e., the gravity equation, fails to predict trade (im)balances "miserably". To reach this conclusion, Davis and Weinstein (2002) use a canonical gravity model and plot fitted against actual bilateral trade balances. Their main finding is that the gravity model predicts balances that are an order of magnitude smaller than the corresponding actual balances. In addition, Davis and Weinstein (2002) run a regression that obtains a coefficient of fitted on actual trade balances that is only 0.06, with a corresponding $R^2 = 0.07$. Based on these results and based on similar findings at the sectoral level, Davis and Weinstein (2002) conclude that the canonical gravity model fails to explain bilateral trade balances and dub this failure 'The Mystery of the Excess Trade Balances'.

If the results of Davis and Weinstein (2002) hold up to scrutiny, then this would shed doubt about the overall validity of the structural gravity equation as one of the most successful empirical models in (international) economics, c.f., Costinot and Rodriguez-Clare (2014) and Head and Mayer (2014). In addition, it would also cast a shadow over the many quantitative trade models that are built around the gravity equation, c.f., Arkolakis et al. (2012) and Costinot and Rodriguez-Clare (2014). In particular, if the workhorse model cannot explain bilateral imbalances, then there might be an intellectual basis for the claim that those are due to some 'unfair' (asymmetric) manipulation of trade costs by trade partners.

In this paper, we show that this is not the case: In fact, the gravity model does a good job in predicting trade imbalances. There is no 'mystery of the excess trade balances'. In our analysis, we capitalize on three major innovations in the theoretical and empirical gravity literature since Davis and Weinstein (2002) that move gravity estimations closer in line with theory. First, following the recommendations of Anderson and van Wincoop (2003) we adjust the specification of Davis and Weinstein (2002) to introduce properly defined multilateral resistance terms and country-specific size variables. Second, consistent with gravity theory, c.f., Arkolakis et al. (2012) or Ramondo et al. (2016), and following the estimation recommendations of Yotov et al. (2016), we estimate the gravity model with consistently constructed *intra-national* trade flows, in addition to the standardly used international trade flows. Third, following Santos Silva and Tenreyro (2006; 2011), we estimate the gravity model with the Poisson Pseudo Maximum Likelihood (PPML) estimator.[3]

To perform the main analysis we employ the dataset of Baier et al. (2016), which includes consistently constructed intra-national and international manufacturing trade flows. To demonstrate that the main finding of Davis and Weinstein (2002) was not an artifact of the specific data that they used, we reproduce the results from the original specification of Davis and Weinstein (2002) with the trade data of Baier et al. (2016). We replicate the main finding of Davis and Weinstein (2002): the gravity model predicts balances that are an order of magnitude smaller than the corresponding actual balances. The regression coefficient of fitted imbalances on actual trade imbalances is equal to 0.08 with an R^2 of 0.05. So, the mystery of the excess trade balances is also present in the dataset of Baier et al. (2016); our main results cannot be attributed to our different dataset.

Using those data, we carry out the same comparison as Davis and Weinstein (2002) and implement the three aforementioned adjustments. The mystery of the excess trade balances disappears! A graphical illustration reveals that the points capturing actual vs. predicted balances are aligned close to a 45-degree line. In addition, the regression coefficient of fitted imbalances on actual trade imbalances is equal to 0.76 (as compared to the original 0.06) and the R^2 equal to 0.87 (as compared to the original 0.07). A series of sensitivity experiments including (i) sectoral estimations, (ii) yearly estimations, (iii) the use of aggregate data from World Input-Output Database (WIOD) as an alternative dataset, and (iv) very detailed

[3]Better modeling of bilateral trade costs, especially in combination with the introduction of intra-national trade flows, is a fourth possible improvement to the original specification of Davis and Weinstein (2002). While we are able to quantify the potential contribution of this adjustment, we do not implement it in our main analysis due to its ad hoc nature. Instead, we only implement the aforementioned three adjustments and we show that these are sufficient for the gravity model to predict bilateral trade balances quite well.

sectoral estimations using the same data, all confirm the robustness of our main finding: The modern incarnation of the gravity model is well suited to predict bilateral trade balances.

So what explains the (im)balances? We perform two variance decomposition experiments in order to measure the relative importance of several competing factors to explain the bilateral trade balances. First, we distinguish between country-specific and bilateral determinants of the trade imbalances. Our analysis reveals that most of the variation (about two-thirds) in bilateral trade balances is due to country-specific forces. Second, we decompose the influence of bilateral trade costs into the contributions of symmetric trade costs that are measured by gravity variables vs. symmetric trade costs that are measured by pair fixed effects vs. asymmetric trade costs. We find that, in our sample, asymmetric trade costs explain only between 11 and 13% of the variance in bilateral balances. The small relative importance of asymmetric bilateral trade costs is confirmed for alternative years, with sectoral data, and with an alternative dataset.

There are two main conclusions that we draw from this analysis. First, improving the modeling of bilateral trade costs, even when they are still fully symmetric, leads to improvements in the prediction of trade imbalances. Why? In the presence of aggregate trade imbalances, even with symmetric direct bilateral trade costs, the total bilateral trade costs, which include the multilateral resistance terms, are asymmetric and this explains the good fit of the gravity model with respect to trade imbalances. Second, the fact that asymmetric trade costs do not matter much has an important policy implication: bilateral trade balances are best addressed by bringing country-level revenue and expenditure in line, not by manipulating bilateral trade costs (tariffs, non-tariff barriers, exchange rates and so on).

Having shown that the gravity model is successful in predicting bilateral trade balances, and given the political buzz around them, we use the model conduct two simple general equilibrium experiments. In the first, we assume that the US adopts policies that affect its entire aggregate trade balance: i.e., policies that shift the balance of national saving and investment. The question is: which bilateral relationships will be most affected? In the second experiment, we assume that the EU and the US conclude a free trade agreement (FTA). Will this FTA lower the chronic bilateral deficit in goods trade that the US have with EU countries, such as Germany, or do just the opposite? We find that an exogenous change in the aggregate balance falls most strongly on bilateral links which feature strong bilateral imbalances with the US initially. We also find that an FTA exacerbates bilateral trade imbalances rather than remedies them.

Our paper is related to various strands of research. We already mentioned the scant literature on bilateral trade balances, including the empirical study of Davis and Weinstein (2002) and also Reyes-Heroles (2016), who studies the relationship between trade costs and trade imbalances in a general equilibrium setting, as well as Dekle et al. (2007) who perform a macroeconomic rebalancing exercise by setting all aggregate trade balances to zero and showing how bilateral balances would adjust and how welfare would be affected across the globe. Cunat and Zymek (2018) develop and calibrate a structural gravity model, but find – different to us – that large asymmetric trade costs are needed to explain the empirical patterns. We also mentioned some of the most influential papers from the recent structural gravity literature, i.e., Arkolakis et al. (2012) Costinot and Rodriguez-Clare (2014) and Head and Mayer (2014). To that list, we have to add the first theoretical gravity model of Anderson (1979) as well as the two seminal papers of Eaton and Kortum (2002) and Anderson and van Wincoop (2003) that popularized the structural gravity model in the early 2000s.

In spirit and approach, our paper is related to several studies that resolve prominent puzzles in the economics literature by capitalizing on theoretical developments. Most notably, Anderson and van Wincoop (2003) resolve the "Canadian Border Puzzle" of McCallum (1995) by introducing and properly controlling for the structural multilateral resistance terms. Yotov (2012) resolves the "Distance Puzzle of International Trade", c.f., Disdier and Head (2008), and "Missing Globalization Puzzle", c.f., Coe et al. (2002) by recognizing that the theoretical gravity system can only identify relative trade costs and that the puzzles disappear once the effects of globalization are measured relative to the changes in domestic trade costs. Most recently, Ramondo et al. (2016) stress the counterfactual positive correlation between country size and welfare implied by the standard gravity model. They show that properly accounting for domestic trade frictions eliminates this empirical issue.

The remainder of this paper is structured as follows. Section 2 reproduces the Davis and Weinstein (2002) puzzle in our data set. Section 3 shows how the puzzle disappears when modern gravity tools are applied, and shows that our findings are robust to using different time periods, disaggregate data, and different trade data. Section 4 analyzes the contribution of alternative factors that contribute to the success of gravity in predicting trade imbalances. Section 5 presents the results of our general equilibrium experiments. Section 6 concludes.

2 The Mystery of the Excess Trade Balances

This section describes the 'The Mystery of the Excess Trade Balances' and reproduces the analysis of Davis and Weinstein (2002) to demonstrate that the mystery is present in an alternative and more recent dataset of international trade. First, we present the econometric gravity model as it appears in Davis and Weinstein (2002):

$$\begin{aligned} \ln E_{cc'} &= \beta_0 + \beta_1 \ln(s_{c'} X_c) + \beta_2 \ln(DIST_{cc'}) + \beta_3 \ln(REMOTE_c) \\ &\quad + \beta_4 ADJ_{cc'} + \beta_5 FTAEC_{cc'} + \epsilon_{cc'}, \end{aligned} \tag{1}$$

where $E_{cc'}$ denotes exports from country c to country c'. $s_{c'}$ is the world share of spending of importer c', which is constructed as the GDP of country c' plus its current account as a share of world GDP. X_c is the GDP of exporter c. $DIST_{cc'}$ is the bilateral distance between countries c and c'. $REMOTE_c$ is a remoteness index for exporter c, which is constructed as an inverse distance-weighted average of rest-of-world GDP's. $ADJ_{cc'}$ is an indicator variable for a common border between countries c and c'. Finally, dummy variable $FTAEC_{cc'}$ takes a value of one if both countries in a pair were part of NAFTA or the EC, and it is equal to zero otherwise.[4]

[4]The only difference between equation (1) and the original specification from Davis and Weinstein (2002) is that in their specification (see their equation 7 on page 172) the ADJ and the FTAEC variables appear in logs. We believe that this is a typo since ADJ and FTAEC are indicator variables and, therefore, they

Davis and Weinstein (2002) estimate equation (1) on a cross-section of data for the year 1996. Then, they take the exponential of the fitted values to calculate estimated bilateral trade balances, $\hat{E}_{cc'} - \hat{E}_{c'c}$, and they plot them against the actual bilateral trade balances $E_{cc'} - E_{c'c}$. The results appear in Figure 1 of Davis and Weinstein (2002), which is included as Panel A of Figure 1 of this paper. As noted by Davis and Weinstein (2002), Panel A of Figure 1 reveals that the gravity model predicts balances that are an order of magnitude smaller than the actual imbalances.

In addition to the visual presentation of the mystery of the excess trade balances, the authors offer a series of other statistics, which we report in Panel A of Table 1. Specifically, they construct the ratio of the variance of predicted balances to actual balances to find that it is just 0.05. Another interesting result is that the gravity model performs very poorly even to predict the sign of the bilateral trade balances. It is successful only 54 percent of the time. Finally, the authors run a regression that obtains a coefficient of fitted imbalances on actual trade imbalances that is equal to 0.06 and an R^2 value of 0.07. Based on these results and based on similar findings that are obtained at the sectoral level, Davis and Weinstein (2002) conclude that the canonical gravity model fails to explain actual bilateral trade balances. They call this failure 'The Mystery of the Excess Trade Balances' and argue that standard explanations of bilateral imbalances based on triangular trade or the distribution of aggregate balances over trade partners have little to offer, neither on the aggregate nor on the sectoral level.

Next, we reproduce the results from Equation (1) and from Figure 1 of Davis and Weinstein (2002) with an alternative dataset. This dataset is constructed by Baier et al. (2016). It covers manufacturing trade and has several features that are needed for the estimation of the gravity equation that we develop in the next section. Specifically, in addition to international trade flows, the dataset also includes internal trade flows. In addition, it can be used to construct total output and total expenditures. For the purpose of replicating the analysis

should enter equation (1) in levels.

of Davis and Weinstein (2002), we only employ the international trade flows from the Baier et al. (2016) database. The rest of the variables from equation (1) come from several sources. Data on bilateral distances and common borders stem from the CEPII distances database, data on trade agreements from Mario Larch's RTA database. Finally, data on GDP and the current account are from the World Bank's World Development Indicators.

We use a cross-section of data from Baier et al. (2016) pertaining to the year of 2000 and follow the steps from Davis and Weinstein (2002) to obtain the results in Panel B of Figure 1, which confirms the original findings of Davis and Weinstein (2002).[5] Also similar to them, in Panel B of Table 1, we find that the ratio of the variance of predicted balances to actual balances is very small, just 0.15. In addition, we find that the gravity model predicts the sign of the bilateral trade balances correctly only in 53% of the cases. We also regress fitted imbalances on actual trade imbalances and find a coefficient of 0.08 and an R^2 of 0.05. Based on these results we conclude that the mystery of the excess trade balances is present in the data from Baier et al. (2016) and we proceed to solve the mystery in the next section.

3 Solving the Mystery of the Excess Trade Balances

Capitalizing on the latest developments in the theoretical and in the empirical gravity literatures, we propose three adjustments to the gravity specification of Davis and Weinstein (2002) and we demonstrate that, in combination, these improvements resolve the mystery of the excess balances. We proceed in four steps. First, we very briefly review the structural gravity model. Then, we introduce and motivate each of the proposed adjustments. Third, we combine these adjustments to obtain a new version of the empirical gravity equation, which we compare to the original specification of Davis and Weinstein (2002). Finally, we estimate our gravity model with the same dataset that we used in the previous section and show that the mystery of the trade balances is solved.

[5] We pick the year 2000, because results are most striking for that particular cross-section; however, using 1996 (as Davis and Weinstein (2002)) yields very similar results; see our sensitivity analysis.

As famously demonstrated by Arkolakis et al. (2012), the following structural gravity equation is representative of a very wide class of underlying general equilibrium trade models:[6]

$$E_{cc'} = \frac{Y_c E_{c'}}{Y} \left(\frac{t_{cc'}}{\Pi_c P_{c'}} \right)^{1-\sigma} \qquad \forall c, c', \tag{2}$$

where $E_{cc'}$ is defined earlier as the exports from c to c'. Y_c is the value of output in origin c, $E_{c'}$ is the value of expenditure at destination c', and Y denotes the value of world output. $t_{cc'}$ denotes the bilateral frictions that act directly on trade flows between c and c', e.g., bilateral distance, tariffs, etc. In addition to the direct bilateral frictions, $t_{cc'}$, the total bilateral trade cost term includes the multilateral resistances of Anderson and van Wincoop (2003):

$$(P_{c'})^{1-\sigma} = \sum_c \left(\frac{t_{cc'}}{\Pi_c} \right)^{1-\sigma} \frac{Y_c}{Y}, \tag{3}$$

$$(\Pi_c)^{1-\sigma} = \sum_{c'} \left(\frac{t_{cc'}}{P_{c'}} \right)^{1-\sigma} \frac{E_{c'}}{Y}. \tag{4}$$

The multilateral resistances are general equilibrium trade cost terms that consistently aggregate bilateral trade costs on the consumers and on the producers in each country as if they were, respectively, buying from and shipping to a single/unified world market.[7] If trade were frictionless, i.e., if $t_{cc'} = 1$ for all c, c', then theory implies that the right-hand side of equation (2) collapses to $(Y_c E_{c'})/Y$. Thus, one can interpret the term $\left(\frac{t_{cc'}}{\Pi_c P_{c'}} \right)^{1-\sigma}$ as a measure of total bilateral trade frictions that drive a wedge between realized trade flows, $E_{cc'}$, and frictionless trade, $(Y_c E_{c'})/Y$.

Guided by equation (1), the first theoretically-motivated adjustment that we propose to the original specification of Davis and Weinstein is to control properly for the country-size variables, i.e., Y_c and $E_{c'}$, and for the structural multilateral resistances, $(\Pi_c)^{1-\sigma}$ and

[6] We refer the reader to Anderson (2011), Costinot and Rodriguez-Clare (2014), Head and Mayer (2014), and Yotov et al. (2016) for recent surveys of the theoretical structural gravity literature.

[7] When trade costs are symmetric, and in absence of aggregate trade imbalances, the model implies that all bilateral balances are zero. Below, we find that aggregate imbalances explain the lion's share of bilateral imbalances; trade cost asymmetries are not essential to match data and theory.

$(P_{c'})^{1-\sigma}$. It has become customary in the empirical gravity literature (e.g., Hummels (2001) and Feenstra (2004)) to use exporter and importer fixed effects to control for the multilateral resistances. It is important to note that our results will be obtained using the structural country-specific gravity terms, including the size variables and the multilateral resistances directly in our estimating equations. There are two possible (and equivalent) approaches to achieve this. One possibility is to implement the original iterative procedure of Anderson and van Wincoop (2003). The other alternative is to capitalize on the additive property of the Poisson Pseudo Maximum Likelihood (PPML), c.f. Arvis and Shepherd (2013) and Fally (2015), which allows PPML to be used as a non-linear solver to recover the multilateral resistances. The two approaches deliver identical results. However, for computational simplicity, we will rely on the PPML estimator.

Moreover, following Santos Silva and Tenreyro (2006; 2011), we favor PPML over OLS because, due to heteroskedasticity, the OLS estimator delivers not only biased but also inconsistent gravity estimates. Santos Silva and Tenreyro (2006; 2011) show that the PPML estimator addresses this deficiency. In addition, due to its multiplicative form, the PPML estimator takes into account the information that is contained in zero trade flows. The OLS estimator throws this potentially useful and important information away. This is our second adjustment to the original specification of Davis and Weinstein

Our third adjustment is also motivated by theory. Specifically, the dependent variable in gravity estimations should include not only international trade flows but *intra-national* trade flows as well. First, the inclusion of intra-national trade flows is consistent with structural gravity theory, as captured by equation (1). Second, the use of intra-national trade flows allows for identification of domestic frictions. As demonstrated by Ramondo et al. (2016), this removes the counterfactual prediction that larger countries should be much richer than smaller ones. Third, following Yotov (2012), the use of intra-national trade flows ensures proper measurement of the evolving impact of distance and globalization in the structural gravity model. Finally, the inclusion of intra-national trade flows allows for identification of the effects of country-specific determinants of trade flows, c.f., Beverelli et al. (2017), as well as non-discriminatory effects of trade policies, c.f., Heid et al. (2017) which, in turn, allow for the identification of asymmetric trade costs.

In combination, our three adjustments lead to the following estimating gravity model:

$$\begin{aligned} E_{cc'} &= \exp[\beta_0 + \beta_1 \ln(Y_c) + \beta_2 \ln(E_{c'}) + \beta_3 \ln\left(\Pi_c^{1-\sigma}\right) + \beta_4 \ln\left(P_{c'}^{1-\sigma}\right) + \beta_5 \ln(DIST_{cc'})] \times \\ & \quad \exp[\beta_6 ADJ_{cc'} + \beta_7 FTA_{cc'} + \beta_8 SMCTRY_c + \beta_9 SMCTRY\_GDP_c] + \epsilon_{cc'}. \end{aligned} \quad (5)$$

Here, in addition to using the theoretically-motivated variables for country-size and multilateral remoteness along with the original proxies for bilateral trade costs from Davis and Weinstein (2002), we have added two new variables due to the introduction of intra-national trade flows. Specifically, $SMCTRY_c$ is a dummy variable that takes a value of one for domestic trade, and it is equal to zero otherwise, and $SMCTRY\_GDP_c$ is defined as the interaction between $SMCTRY_c$ and national GDP. In principle, we could model both international and domestic trade costs better, with more proxies and/or with country-specific fixed effects. However, we do not want to inflate the model with too many a-theoretical trade cost variables.[8] In the robustness analysis, we experiment with alternative specification of the trade costs in our econometric model and we discuss implications.

We apply the proposed adjustments to the same data that we employed in the previous section to obtain Figure 2. The puzzle disappears. The points capturing actual vs. predicted balances are close to a 45-degree line in Figure 2. In addition, Panel C of Table 1 reports a regression coefficient of fitted imbalances on actual trade imbalances equal to 0.76 (as

[8]In addition to allowing for asymmetric country-specific trade costs, there are many other improvements that we could introduce to the modeling of bilateral trade costs in Davis and Weinstein (2002). For example, following Eaton and Kortum (2002), we could split the distance variable into intervals. In addition, following Baier et al. (2016), we could allow for agreement-specific and directional/asymmetric effects of trade agreements. We could also introduce a series of additional proxies for trade costs, e.g., WTO membership, currency unions, etc. Finally, we could employ pair fixed effects to capture all time-invariant bilateral determinants of trade flows in a panel setting. In order to avoid any criticism that the fit of our model is driven by inflating the predictive power through the a-theoretical bilateral trade costs channel, we will obtain our main results with the same trade cost proxies from the original specification of Davis and Weinstein (2002).

compared to the original 0.08) and an R^2 value of 0.87 (as compared to 0.05). Moreover, the ratio of the variance of predicted balances to actual balances is significantly higher 0.67 (as compared to 0.15). Furthermore, the improved gravity specification predicts the sign of the bilateral trade balances correctly in 69% of the cases (as compared to 53%). Based on these results we conclude that the mystery of the excess trade balances is resolved once the gravity model is estimated in accordance with the latest developments from the literature.

Before we show which amendments to the gravity equation matter most for its empirical success, we briefly report the results from a series of sensitivity checks, which all appear in the Supplementary Appendix. First, we confirm our results with data for every year of the manufacturing dataset of Baier et al. (2016). Overall, the estimates across years are similar with moderate variation, thus demonstrating that the structural gravity model performs well in each year of the sample. Next, we make use of the sectoral dimension of the data from Baier et al. (2016) to find that the structural gravity model performs well for each broad manufacturing sector. However, there is some systematic variation across sectors. For example, the fit is not as good for the Food industry, while it is best for Wood manufacturing products. The variation in the fit of the model across sectors points to the need and opportunity to model sector-specific (possibly asymmetric) trade costs better.

We also obtain estimates with an alternative dataset. Specifically, we employ the WIOD dataset, c.f., Timmer et al. (2015), which has several advantages and some caveats. On the positive side, WIOD offers complete sectoral coverage for the countries in the data and this database includes consistently constructed intra-national trade flows. The downside of WIOD is that country coverage is limited (to 43 countries) and that the trade data has been adjusted to match the underlying IO linkages. With these caveats in mind, we obtain sectoral trade balance estimates for the first and for the last year (2000 and 2014, respectively) of the WIOD dataset. Overall, the results confirm our main findings and they are similar across the two years. We also document some differences across sectors.

4 Variance Decomposition

Having shown that the gravity model is successful in predicting bilateral trade balances, in this section we ask: What contributes to explain bilateral trade balances? While we cannot offer an analytical answer to this question, we perform two simple variance-decomposition exercises that allow us to draw reduced-form evidence about the relative importance of several alternative and competing factors that explain the trade balances. All experiments share a common approach. In each case, we construct predicted trade flows from an alternative specification of the empirical gravity model. Then, we construct bilateral trade balances and we regress them on the actual trade balances from our data. Finally, we report the same statistics as in Davis and Weinstein (2002)).

In the first decomposition exercise we distinguish between country-specific trade balance determinants (such as the stance of fiscal and monetary policies) vs. bilateral factors (such as exchange rates, tariffs, or other trade costs). Our findings are presented in Table 2. The dependent variable (predicted trade balances) in Panel A is constructed based on a gravity specification that only relies on country-specific covariates, i.e., we do not use any of the bilateral covariates from specification (5). The dependent variable in Panel B is constructed after adding geography gravity variables (i.e., distance and and adjacency) to the country-specific variables from the specification in Panel A. Finally, the dependent variable in Panel C is based on a gravity model that also employs the dummy variable for trade agreements, i.e., this is exactly our main specification (5).

Based on the indicators in Table 2, we conclude that the largest share of the variation (about two-thirds) in bilateral trade balances is due to country-specific forces. We also note that better modeling of bilateral trade costs improves the fit. However, we cannot attribute the change in the indicators between Panels A and B exclusively to direct bilateral trade frictions because, presumably, the better modeling of the direct bilateral trade costs also leads to better fit of multilateral resistances. Finally, as indicated by the diagnostics reported in Panel D, which are constructed as the difference between the indicators in Panel

C and a hypothetical perfect fit, we conclude that, even when trade costs are proxied by the standard (and symmetric) gravity variables, there is little room left for asymmetric trade costs to improve the fit of the structural gravity model. We further explore the importance of trade costs in our second experiment.

From 2 3 and 4 it follows that the structural gravity model cannot generate bilateral trade imbalances when trade costs are symmetric and there are no aggregate trade imbalances. Stimulated by this result, in the second experiment we study the importance of proper modeling of bilateral trade costs for successfully predicting trade balances.[9] Our findings appear in Table 3. The difference between the three panels is in the definition of bilateral trade costs that are used to predict trade flows in a structural gravity specification. The dependent variable (predicted trade balances) in Panel A are constructed based on symmetric trade costs that are obtained in a cross section with standard gravity variables. Specifically, in addition to the four country-specific covariates (2 size variables and 2 multilateral resistances), this specification only includes three gravity variables, namely $DIST_{cc'}$, $ADJ_{cc'}$ and $SMCTRY_c$. The goodness of fit statistics in Panel A are far from perfect; however, even this simple specification delivers a strong fit.

The dependent variable in Panel B of Table 3 is based on predictions that are obtained from an underlying panel estimation, where bilateral trade costs are proxied by symmetric pair fixed effects and one border variable for each year in the sample. Thus, once again, the underlying bilateral trade costs vector is fully symmetric. For consistency with the estimates from Panel A, the diagnostics in Panel B are obtained only for the year 2000. The main message from Panel B is that improving the modeling of bilateral trade costs, even when they are still symmetric, leads to improvements in the predictions of the trade imbalances. At first, this result may seem at odds with Anderson and van Wincoop (2003). However, the important difference in our setting is that we have aggregate trade imbalances, which lead to asymmetric total trade costs, $\left(\frac{t_{cc'}}{\Pi_c P_{c'}}\right)^{1-\sigma}$, even with symmetric direct bilateral trade

[9]We thank Peter Neary for very stimulating discussions on these issues.

costs, t_{ij}. We demonstrate that this is indeed the case in Figure 3, where, in the top panel, we plot the direct bilateral trade costs from the underlying gravity model, while the total trade costs in each direction appear in the bottom panel of Figure 3.

Finally, the dependent variable in Panel C is based on predictions that are obtained from the same panel estimation that we used to obtain the estimates in Panel B, with the only difference that we have replaced the symmetric bilateral fixed effects with asymmetric pair fixed effects. As expected the fit improves significantly and it is almost perfect for all but one of the indicators presented in Panel C. The only statistic that can be improved further is the prediction of the sign. The gravity model with asymmetric pair fixed effects fails to predict correctly the sign of the trade balances for small trade flows between smaller and relatively less developed economies, e.g., Costa Rica, Malta, Ecuador, the Philippines, and Greece.

The decomposition exercises in Tables 2 and 3 pertain to the year 2000. However, in our robustness experiments, we find that the overall picture is robust over time and across the manufacturing sectors in our data.[10] We do not need large asymmetric trade costs to explain the variance in bilateral balances. This is a politically relevant result. It suggests that asymmetries in bilateral trade costs (as caused by bilateral differences in the use of tariffs or non-tariff barriers, or exchange rate misalignments) are of much smaller importance than country-level determinants driven by fiscal and monetary policies or institutions. A country – such as the US – trying to reduce bilateral imbalances should therefore focus on those country-specific factors. Asymmetric trade costs explain little of the variation in bilateral balances observed in the data. Hence, a deficit is best addressed by reducing domestic expenditure while boosting revenue, and pushing trade partners to engage into opposite adjustment. Manipulating trade costs is likely to have less of an impact. This is a result that policy makers interested in bilateral balances should pay heed to.

[10] See the Supplementary Appendix for details.

5 General Equilibrium Implications

This section presents the results of two counterfactual experiments, which relate to current policy debates. In each case, we obtain general equilibrium results within a standard gravity model, following Costinot and Rodriguez-Clare (2014).[11] First, we investigate the impact on bilateral balances for (exogenous) changes in US aggregate trade balance. Second, we study the implications of bilateral symmetric trade liberalization between US and EU on the bilateral trade balances between the two regions. For both experiments we employ the WIOD data for three reasons: (i) it covers all sectors in each economy, i.e., it offers complete coverage for each country in the sample; (ii) it includes intra-national trade flows and consistent production and expenditure data which are crucial for the general equilibrium analysis; and (iii) it covers all EU countries, which is important for the second experiment.

Before we continue with the first counterfactual, we note that in 2014, which is the last year in the sample that will serve as the baseline for our experiments, the WIOD data indicates that the United States runs a small aggregate deficit overall. The ratio between total US expenditure and total US output is $\phi_{USA} = E_{USA}/Y_{USA} = 1.010$.[12] Therefore, in order to perform the analysis, we experiment by increasing the trade deficit using exogenous changes in ϕ_{USA} by successively increasing it to 1.1, 1.2, and 1.4. Then, for the sake of completeness, we also experiment by generating trade surpluses by using values of ϕ equal to 0.9, 0.8, and 0.6.

Table 4 presents our main results for the changes in the bilateral US trade balances in response to changes in the aggregate US trade balance.[13] The first column of the table lists the countries and the second column assigns country IDs by ranking the US partners

[11]For simplicity, we focus on a simple one-sector general equilibrium gravity model, recognizing that the introduction of sectors and intermediates, as in Caliendo and Parro (2015) or of dynamics, as in Eaton et al. (2016) or Anderson et al. (Accepted) will only affect our findings quantitatively.

[12]The WIOD data deviates from official data as published by the US Bureau of Economic Analysis, according to which $\phi_{USA} = 1.021$ in 2014 (current account balance).

[13]The results in Table 4 are obtained with calibrated trade costs. Analysis that are obtained with calibrated trade costs with cross-section data are identical as expected. In the Supplementary Appendix we demonstrate that the main qualitative conclusions are confirmed with estimated trade costs that are obtained from a panel specification, as well as with estimated trade costs that are obtained from a cross-section specification.

depending on the trade balance. The third column lists the predicted trade balance.[14] The estimates in the next three columns are obtained by progressively increasing the aggregate US trade deficit. Finally, the estimates in the last three columns are obtained by simulating and increasing aggregate trade surplus.

Two main findings stand out from Table 4. First, an increase in the aggregate trade deficit leads to more trade deficits with each partner and vice versa. Second, the bilateral changes in response to an aggregate trade deficit is larger for the countries that are more tightly related to US, e.g., Mexico, which have lower trade costs to start with. An implication is that a change in the aggregate trade balances affects the closest trading partners most. They would have to bear the largest portion of any macroeconomic rebalancing. We find these conclusions to be simple, intuitive and robust.

Next, we move on to our second experiment, which studies the impact on the US trade balances with the EU from a symmetric bilateral trade liberalization. Specifically, to obtain such effects we simulate the effects of a free trade agreement that will have partial effects corresponding to hypothetical gravity estimates of $\hat{\beta}_{FTA} = 0.4$ and $\hat{\beta}_{FTA} = 0.8$.[15] In this experiment we rely on calibrated trade costs. However, based on the previous analysis and on the new results themselves, we should expect qualitatively identical results with estimated trade costs.

The results are reported in Table 5. As before, the first column of the table lists the countries. The second column assigns country IDs by ranking the US partners depending on the trade balance. The third column lists the trade balances between the US and EU countries. According to the data, US runs a trade deficit (goods and services) with Germany, Great Britain, and Italy and a surplus with countries such as Ireland, Luxembourg or France.[16] The next two columns of Table 5 report the bilateral trade balances between US

[14] As expected with calibrated trade costs the actual and predicted trade balances are identical. Nevertheless, it was reassuring to see that our GE system delivers the expected results.

[15] These are values well in line with the meta analysis in Head and Mayer (2014).

[16] According to the WIOD data, the US ran a small surplus with the EU in 2014; BEA data confirms that the bilateral current account balance was positive in that year.

and each of the EU countries that correspond to $\hat{\beta}_{FTA} = 0.4$ and $\hat{\beta}_{FTA} = 0.8$, respectively.

We draw three conclusions from Table 5. First, symmetric trade liberalization between US and EU increases the bilateral trade surpluses with countries that the US already has surpluses with, and vice versa. Second, the effects are monotonic, i.e. larger decrease in trade costs will lead to larger effects on the trade balances in the same direction. Third, given the initial trade balance between US and EU, the aggregate trade surplus of US with the EU increases due to trade liberalization. Importantly, if the US administration hopes to improve the US' bilateral trade balance with countries such as Germany, it may be disappointed. Similar to our results from the previous experiment, the conclusions from this scenario are simple, intuitive and robust.

6 Conclusion

Capitalizing on the latest developments in the empirical gravity literature and adhering more closely to the structural gravity theory, we resolve the mystery of the excess trade balances from Davis and Weinstein (2002). We find that country-level variables explain about three quarters of the variance in bilateral balances in our sample; together with symmetric trade costs that ratio goes up to about 88%. Hence, the role for trade cost asymmetries in explaining bilateral balances is quite minor. Politicians trying to reduce certain bilateral balances should pay heed to this result.

Our results have implications for partial gravity estimations as well as for general equilibrium analysis with the structural gravity model. Despite the very good performance of the econometric gravity equation in predicting bilateral trade balances, our estimates point to some opportunities for improvement of the modeling of the direct bilateral trade costs in certain sectors, e.g., Mining and Services, and for certain countries, e.g, less developed economies. From a broader perspective, the success of the empirical gravity equation in predicting bilateral trade balances further validates the use of the gravity model for counterfactual analysis and points to potentially fruitful research that combines the structural gravity model of trade with macroeconomic frameworks.

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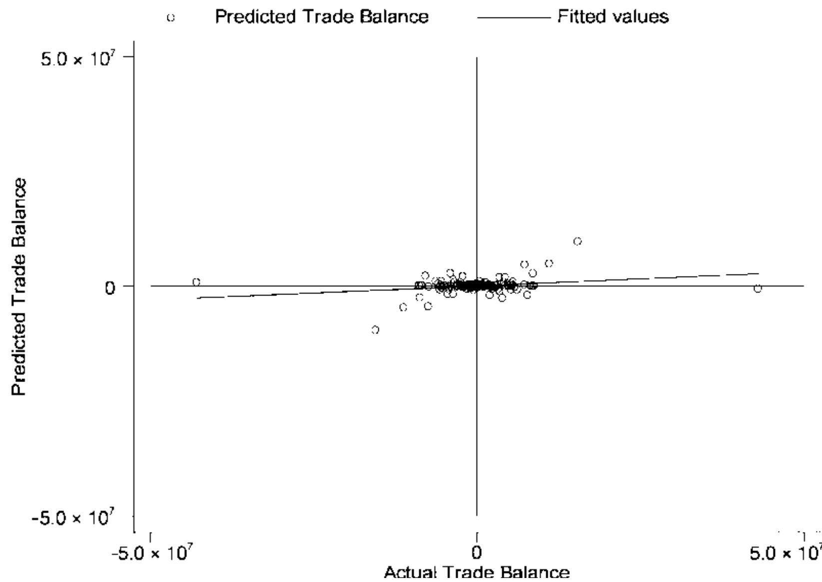
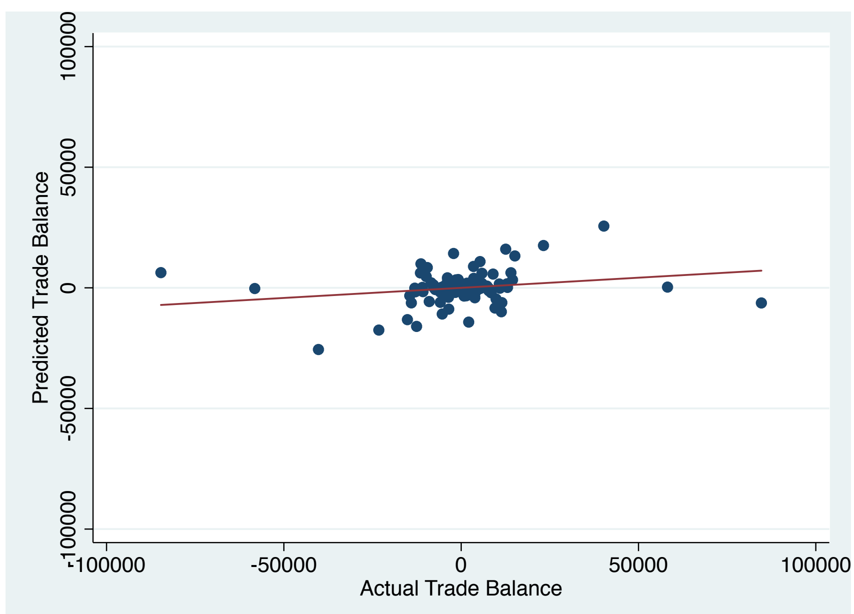
Figure 1: The Mystery of Excess Trade Balances

Panel A. The Mystery in the Original Data



Panel B. New Data, Same Mystery



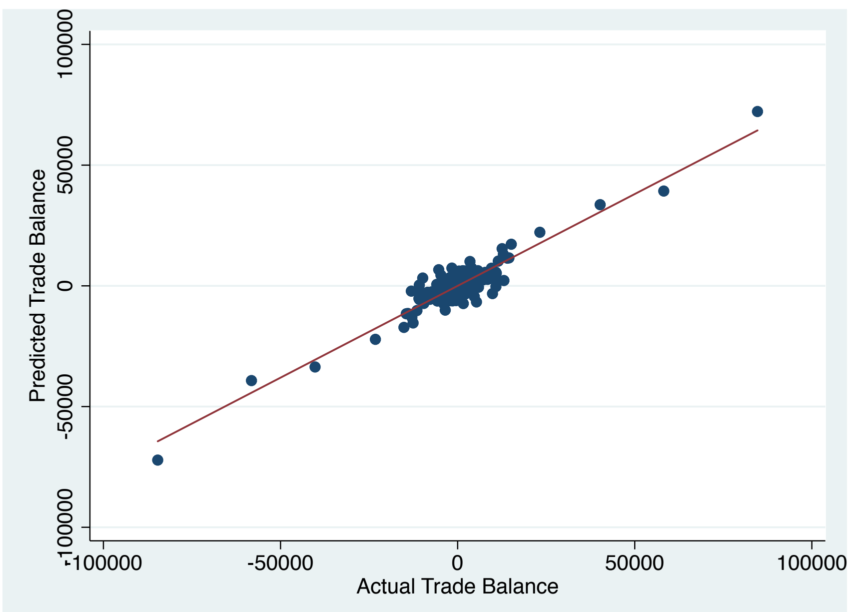
Note: Panel A of this figure is Figure 1 from Davis and Weinstein (2002), which visualizes the mystery of excess trade balances by showing that predicted balances are an order of magnitude smaller as compared to actual balances. Panel B of this figure reproduces Figure 1 from Davis and Weinstein (2002) with the data from Baier et al. (2016). Similar to the original figure of Davis and Weinstein (2002), Panel B visualizes the mystery of excess trade balances by showing that predicted balances are an order of magnitude smaller as compared to actual balances. See main text of this paper and Davis and Weinstein (2002) for further details.

Table 1: The Mystery of Excess Trade Balances

Regression Fit (R^2)	Regression Coefficient	Variance Ratio	Sign (%)
A. Original Specification, Original Data			
0.07	0.06	0.05	0.54
B. Original Specification, New Data			
0.05	0.08	0.15	0.53
C. Structural Gravity Specification, New Data			
0.87	0.76	0.67	0.69

Notes: This table reports estimation results from three OLS regressions of predicted on actual trade balances. The difference between the three panels is in the underlying gravity specifications and the data that are used to predict the bilateral trade flows that are used to construct predicted trade balances. Specifically, the indicators in Panel A are borrowed directly from Davis and Weinstein (2002), i.e., they are based on their original specification and are obtained with their original data. The underlying specification in Panel B is the same as in Davis and Weinstein (2002), however, the data used are from Baier et al. (2016). Finally, the numbers in Panel C are obtained with the new data from Baier et al. (2016) and with a specification that implements recent developments in the estimation of gravity equations. See text for further details.

Figure 2: The Mystery Solved



Note: This figure reproduces Figure 1 from Davis and Weinstein (2002) with the data from Baier et al. (2016) and after introducing the three adjustments to the original specification of Davis and Weinstein (2002), which we describe in the text. The figure demonstrates that with these improvements the mystery of the excess trade balances is resolved. See text for further details.

Table 2: Variance Decomposition: Country-specific vs. Bilateral Factors

	Regression Fit (R^2)	Regression Coefficient	Variance Ratio	Sign (%)
A. Country-specific Variables Only				
	0.77	0.67	0.59	0.67
B. Bilateral Geography				
	0.83	0.70	0.60	0.69
C. Bilateral Policy				
	0.87	0.76	0.67	0.69
D. Remaining Variation (Asymmetric Trade Costs & Measurement)				
	0.13	0.24	0.33	0.31

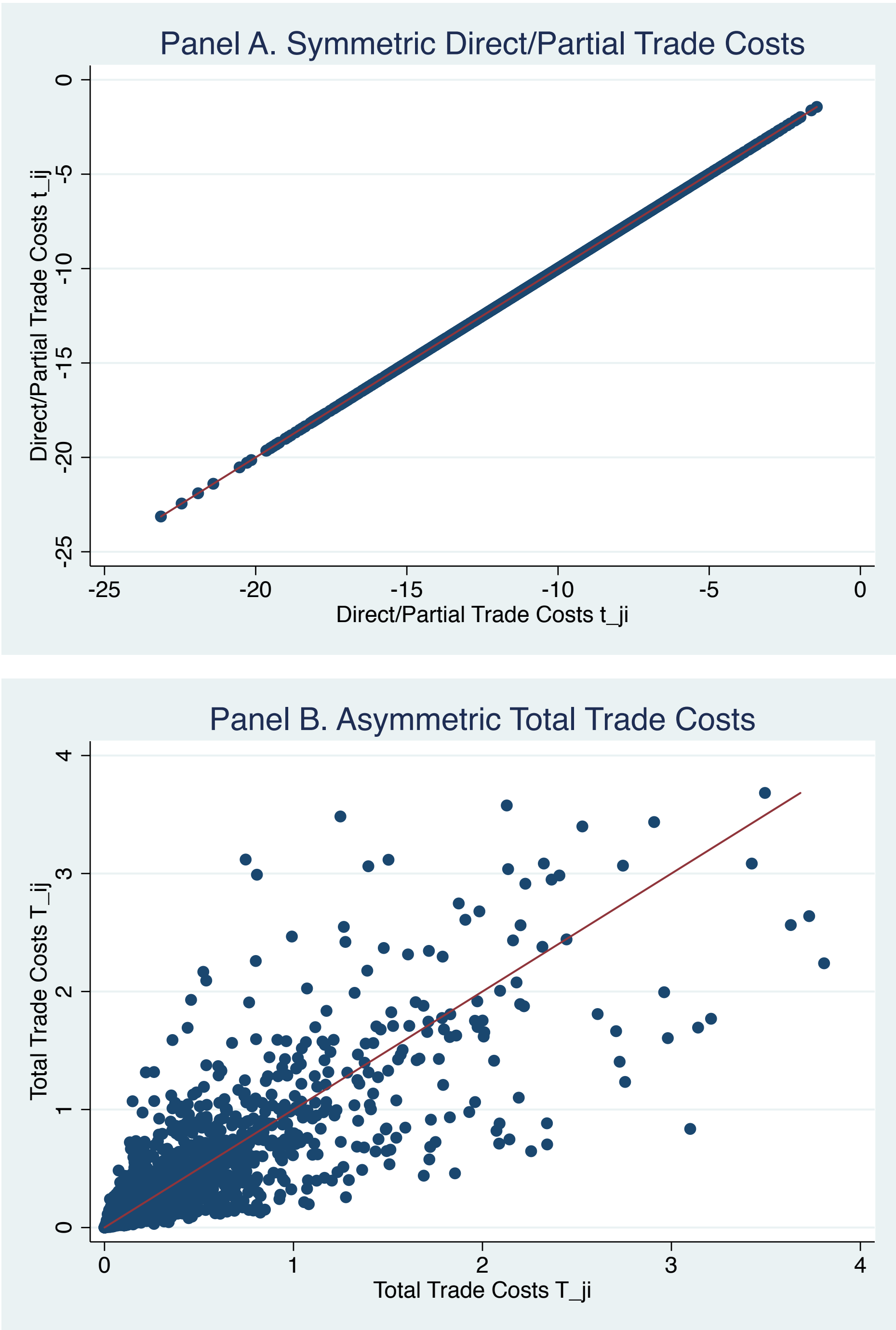
Notes: This table reports estimation results from three OLS regressions of predicted on actual trade balances. The difference between the three specifications is in the underlying gravity specification that is used to predict the bilateral trade flows that are used to construct predicted trade balances. Specifically, the dependent variable (predicted trade balances) in Panel A is constructed based on a gravity specification that only relies on country-specific covariates. The dependent variable in Panel B is constructed after adding geography gravity variables (i.e., distance and contiguity) to the country-specific variables from the specification in Panel A. The dependent variable in Panel C is based on a gravity model that also employs a dummy variable for trade agreements, i.e., this is our main specification (5). Finally, the indicators in Panel D are constructed as the difference between the indexes in Panel C and the corresponding numbers from a hypothetical gravity specification that delivers perfect fit. See text for further details.

Table 3: Variance Decomposition: Trade Costs

	Regression Fit (R^2)	Regression Coefficient	Variance Ratio	Sign (%)
A. Symmetric Trade Costs. Gravity Variables.				
	0.75	0.61	0.50	0.68
B. Symmetric Trade Costs. Symmetric Pair Fixed Effects				
	0.88	0.87	0.87	0.74
C. Asymmetric Trade Costs. Directional Pair Fixed Effects				
	0.99	1.00	1.02	0.87

Notes: This table reports estimation results from three OLS regressions of predicted on actual trade balances. The difference between the three specifications is in the definition of bilateral trade costs that are used to predict trade flows in a structural gravity specification. Specifically, the dependent variable (predicted trade balances) in Panel A are constructed based on symmetric trade costs that are obtained in a cross section with standard gravity variables. The dependent variable in Panel B is based on predictions that are obtained from an underlying panel estimation, where bilateral trade costs are proxied by symmetric pair fixed effects. Finally, the dependent variable in Panel C is based on predictions that are obtained from an underlying panel estimation, where bilateral trade costs are proxied by asymmetric/directional pair fixed effects. See text for further details.

Figure 3: Variance Decomposition: Trade Costs



Note: This figure reports trade costs for the year 2000, which are obtained from a panel specification over the period 1988-2006 with exporter-time, importer-time fixed effects. Bilateral trade costs are proxied by symmetric pair fixed effects and time-varying border dummy variables for each year in the sample. Panel A reports the partial/direct bilateral trade costs in each direction of trade flows, as proxied by the estimates of the pair fixed effects int the estimating gravity model. Panel B reports the corresponding total trade costs, as defined in the main text. For clarity, we have dropped the largest 2 percent of the total trade cost estimates. See text for further details.

Table 4: Aggregate vs. Bilateral Trade Balances: GE Effects. Calibrated Trade Costs

		Actual vs. Predicted Balances		Alternative Aggregate Trade Balances (Alternative ϕ's)					
ISO	ID	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Actual	Predicted	1.1	1.2	1.4	.9	.8	.6
CHN	1	-1,139	-1,139	-4,587	-9,659	-22,567	2,079	4,988	11,714
CAN	2	-1,069	-1,069	-2,999	-5,074	-8,759	981	2,367	4,300
JPN	3	-355	-355	-1,744	-3,480	-7,216	1,083	2,262	4,470
DEU	4	-289	-289	-1,729	-3,486	-7,215	1,214	2,390	4,478
KOR	5	-258	-258	-1,248	-2,451	-4,906	778	1,617	3,151
GBR	6	-238	-239	-1,296	-2,557	-5,151	859	1,679	3,060
TWN	7	-225	-225	-725	-1,336	-2,531	258	620	1,261
IND	8	-175	-175	-657	-1,296	-2,740	290	659	1,374
RUS	9	-167	-167	-430	-820	-1,794	40	175	431
CHE	10	-144	-144	-465	-864	-1,692	164	381	744
ITA	11	-125	-125	-588	-1,190	-2,576	338	702	1,385
ESP	12	-63	-63	-292	-594	-1,303	164	341	673
IDN	13	-47	-47	-224	-461	-1,015	131	284	596
AUT	14	-43	-43	-160	-311	-647	69	154	305
LTU	15	-17	-17	-36	-62	-119	-3	4	15
PRT	16	-16	-16	-58	-114	-243	24	54	108
TUR	17	-13	-13	-175	-379	-845	164	316	615
FIN	18	-13	-13	-127	-264	-550	111	211	388
NOR	19	-12	-12	-125	-263	-562	109	206	377
CZE	20	-11	-11	-70	-145	-316	51	101	197
ROM	21	-9	-9	-39	-80	-177	21	45	91
POL	22	-7	-7	-88	-191	-429	81	157	305
EST	23	-2	-2	-8	-16	-34	3	7	15
SVN	24	-1	-1	-7	-15	-34	5	11	21
BGR	25	-1	-1	-11	-25	-56	10	20	38
CYP	27	0	0	-2	-4	-10	2	4	8
LVA	28	1	1	-2	-5	-12	4	8	15
SVK	29	2	2	-11	-26	-62	18	33	63
HRV	30	3	3	-3	-10	-25	12	21	38
MLT	31	5	5	2	-1	-5	10	15	25
HUN	32	9	9	-47	-111	-245	76	134	243
GRC	33	20	20	-5	-31	-88	58	96	171
SWE	34	25	25	-156	-364	-801	238	418	741
DNK	35	35	35	-65	-174	-399	162	274	479
MEX	36	73	73	-1,118	-2,405	-4,630	1,270	2,032	3,071
BEL	37	116	116	-292	-732	-1,581	606	1,004	1,660
BRA	38	123	123	-485	-1,187	-2,686	858	1,502	2,673
AUS	39	164	164	-67	-308	-856	533	935	1,771
FRA	40	202	202	-579	-1,460	-3,310	1,154	1,975	3,456
NLD	41	319	319	-218	-769	-1,818	1,025	1,627	2,626
LUX	42	365	365	236	155	78	587	775	1,044
IRL	43	630	630	146	-299	-977	1,214	1,607	2,095

Notes: This table reports estimation results for the changes in the bilateral US trade balances in response to changes in the aggregate US trade balance. The first column of the table lists the countries and the second column assigns country IDs by ranking the US partners depending on the trade balance. The third column lists the predicted trade balance. The estimates in the next three columns are obtained by progressively increasing the aggregate US trade deficit. Finally, the estimates in the last three columns are obtained by simulating and increasing aggregate trade surplus. See text for further details.

Table 5: Symmetric EU-USA Trade Liberalization & the Trade Balances

ISO	ID	(1)	(2)	(3)
		Actual	$\beta_{PTA} = 0.4$	$\beta_{PTA} = 0.8$
DEU	1	-289	-441	-643
GBR	2	-238	-364	-527
ITA	3	-125	-187	-271
ESP	4	-63	-94	-136
AUT	5	-43	-65	-93
LTU	6	-17	-25	-35
PRT	7	-16	-23	-34
FIN	8	-13	-20	-30
CZE	9	-11	-17	-25
ROM	10	-9	-13	-20
POL	11	-7	-12	-18
EST	12	-2	-4	-5
SVN	13	-1	-2	-3
BGR	14	-1	-2	-3
CYP	15	0	0	0
LVA	16	1	1	2
SVK	17	2	3	4
HRV	18	3	5	7
MLT	19	5	7	9
HUN	20	9	12	17
GRC	21	20	28	40
SWE	22	25	32	41
DNK	23	35	49	68
BEL	24	116	151	196
FRA	25	202	272	368
NLD	26	319	433	578
LUX	27	365	491	646
IRL	28	630	767	892

Notes: This table reports estimation results from a hypothetical symmetric trade liberalization scenario between US and the EU. To obtain the results in this experiment we only rely on calibrated trade costs. However, based on the previous analysis and on the new results themselves, we should expect qualitatively identical results with estimated trade costs. The first column of the table lists the courtesies. The second column assigns country IDs by ranking the US partners depending on the trade balance. The third column lists the trade balances between US and the EU countries. The next two columns of Table 5 report the bilateral trade balances between US and each of the EU countries. respectively. See text for further details.

Supplementary Appendix: Sensitivity Experiments

We use this Appendix to report the results from all sensitivity experiments that we performed in order to test the robustness of our main findings.

- First, in Panel A of Table 6, we confirm our main results with data for every year of the manufacturing dataset of Baier et al. (2016), which covers the period 1998-2006. Overall, the estimates across years are similar with moderate variation but not systematic patters across the years in our main dataset, thus demonstrating that the structural gravity model performs well in each year of the sample.

- Next, we capitalize on the sectoral dimension of the data from Baier et al. (2016). Panel B of Table 6 demonstrates that the structural gravity model performs well for each of the manufacturing sectors in the data. We do note, however, that we observe some systematic variation across sectors. For example, the fit is not as good for the Food industry, while it is best for Wood manufacturing products. The variation in the fit of the model across sectors points to the need and opportunity to model sector-specific (possibly asymmetric) trade costs better.

- We also obtain estimates with an alternative dataset. Specifically, we employ the WIOD dataset, which has several advantages and some caveats. On the positive side, WIOD offers complete sectoral coverage for the countries in the data and this database includes consistently constructed intra-national trade flows. The downside of WIOD is that country coverage is limited (to 43 countries) and that the trade data has been adjusted to match the underlying IO linkages. With these caveats in mind, we obtain sectoral trade balance estimates with WIOD and we report them for the first and for the last year of the sample (2000 and 20014, respectively) in Tables 7 and 8. Overall, the results confirm our main findings and they are similar across the two years. We also document some differences across sectors (e.g., mining and services perform worse on average), which, as noted above, can be used to identify sectors where the modeling of bilateral trade costs can be improved.

- We also perform robustness experiments related to the contribution of asymmetric trade costs to explaining bilateral trade imbalances. Our main results, which appear in Panel B of Table 3, were for the year 2000 and were based on predictions that were obtained from an underlying panel estimation where bilateral trade costs are proxied by symmetric pair fixed effects and one border variable for each year in the sample over the whole period of investigation (1988-2006). The estimates in Table 9 reproduce the indicators from Panel B of Table 3 for each year in our sample. These estimates are based on the same underlying panel gravity estimation used to obtain the results in Panel B of Table 3. The main messages from Table 9 are (i) that the potential role of asymmetric trade costs is relatively small, however (ii) it varies and (iii) seems to increase over time.

  A possible explanation for the varying and increasing potential role of asymmetric trade costs could be that that underlying modeling of the symmetric trade costs with pair fixed effects covers a long period of time. Thus, the average symmetric trade costs estimates may be missing some evolution in symmetric bilateral trade costs over time. To test this hypothesis, the results in Table 10 reproduce the indicators from Panel B of Table 3 for each year in our sample, but this time, the underlying symmetric pair fixed effects are obtained from panel gravity estimations that cover three alternative periods, namely 1988-1994, 1995-2000, and 2001-2006. We see from Table 10 that the fit improves due to the better modeling of the symmetric bilateral trade costs. The fit indicators are also more homogenous across years.

  Finally, Table 11 reproduce the indicators from Panel B of Table 3 for each sector in our sample. These estimates are based on the underlying sectoral panel gravity estimations over the whole period of investigation. Two main findings stand out from

Table 11. First, we see that in most manufacturing sectors there is relatively little room for asymmetric trade costs to improve the fit between actual and predicted trade balances. Second, we observe variation across sectors, e.g., the possible contribution of asymmetric trade costs would be very small for Textiles, Wood, Paper and Machinery, but significantly larger for Chemicals. Based on our previous experiment, we expect that allowing for time-varying symmetric trade costs will leave even less room for possible contributions of asymmetric trade costs.

- The main results in Table 4 are obtained with calibrated trade costs. Table 12 confirms the main qualitative conclusions with estimated trade costs that are obtained from a panel gravity specification. In addition, Table 13 confirms our main findings with estimated trade costs that are obtained from a cross-section gravity specification.

Table 6: Robustness: Manufacturing, 1988-2006

	R^2	Reg.Coeff	Var.Ratio	Sign (%)
A. Over Time, 1988-2006				
1988	0.87	0.75	0.65	0.63
1989	0.85	0.70	0.57	0.65
1990	0.82	0.70	0.60	0.65
1991	0.81	0.67	0.55	0.66
1992	0.84	0.70	0.59	0.69
1993	0.86	0.70	0.57	0.67
1994	0.84	0.69	0.57	0.67
1995	0.78	0.66	0.56	0.67
1996	0.75	0.64	0.56	0.69
1997	0.76	0.64	0.53	0.70
1998	0.82	0.71	0.61	0.72
1999	0.85	0.73	0.63	0.70
2000	0.87	0.76	0.67	0.69
2001	0.86	0.75	0.65	0.70
2002	0.86	0.76	0.67	0.72
2003	0.83	0.74	0.66	0.72
2004	0.82	0.72	0.64	0.73
2005	0.81	0.69	0.59	0.72
2006	0.83	0.69	0.58	0.73
B. Across Manufacturing Sectors				
Food	0.74	0.60	0.48	0.70
Textile	0.92	0.93	0.94	0.72
Wood	0.94	0.99	1.04	0.71
Paper	0.93	1.05	1.17	0.71
Chemicals	0.63	0.46	0.34	0.72
Minerals	0.81	0.80	0.79	0.71
Metals	0.76	0.75	0.73	0.62
Machinery	0.92	0.84	0.77	0.76

Notes: Panel A of this table reproduces the main results from Table 1 for every year of the manufacturing dataset of Baier et al. (2016). Panel B obtains corresponding results for each of the main manufacturing sectors covered in the dataset of Baier et al. (2016). See text for further details.

Table 7: Robustness: WIOD, 2000

Sector	R^2	Reg.Coeff	Var.Ratio	Sign (%)
Crop and animal production	0.64	0.67	0.70	0.76
Forestry and logging	0.95	0.85	0.77	0.77
Fishing and aquaculture	0.81	0.86	0.92	0.73
Mining and quarrying	0.41	0.37	0.34	0.76
Manufacture of food beverages, tobacco	0.80	0.76	0.71	0.73
Manufacture of textiles, apparel, leather	0.73	0.59	0.47	0.72
Manufacture of wood and cork;	0.89	1.14	1.45	0.71
Manufacture of paper and paper products	0.58	0.61	0.64	0.71
Printing and reproduction of recorded media	0.73	0.69	0.65	0.78
Manufacture of coke and refined petroleum	0.84	0.72	0.62	0.66
Manufacture of chemicals and chemical products	0.45	0.42	0.39	0.73
Manufacture of basic pharmaceutical products	0.37	0.31	0.25	0.74
Manufacture of rubber and plastic products	0.71	0.69	0.67	0.75
Manufacture of other non-metallic minerals	0.66	0.64	0.62	0.71
Manufacture of basic metals	0.54	0.53	0.51	0.69
Manufacture of fabricated metal products	0.74	0.69	0.65	0.73
Manufacture of computer, electronic and optical	0.78	0.73	0.68	0.67
Manufacture of electrical equipment	0.66	0.72	0.79	0.73
Manufacture of machinery and equipment n.e.c.	0.76	0.74	0.72	0.68
Manufacture of motor vehicles, trailers and semi-trailers	0.88	0.74	0.62	0.80
Manufacture of other transport equipment	0.74	0.72	0.69	0.76
Manufacture of furniture; other manufacturing	0.85	0.83	0.80	0.73
Repair and installation of machinery and equipment	0.85	0.80	0.74	1.01
Electricity, gas, steam and air conditioning supply	0.67	0.64	0.61	0.67
Water collection, treatment and supply	0.02	-0.24	3.91	0.76
Sewerage; waste collection, disposal;	0.61	0.56	0.51	0.89
Construction	0.43	0.50	0.58	0.70
Wholesale, repair of vehicles and motorcycles	0.98	1.00	1.02	0.80
Wholesale trade, except of vehicles and motorcycles	0.53	0.56	0.60	0.71
Retail trade, except of motor vehicles and motorcycles	0.72	0.65	0.58	0.73
Land transport and transport via pipelines	0.86	0.75	0.66	0.71
Water transport	0.61	0.58	0.55	0.69
Air transport	0.49	0.49	0.48	0.64
Warehousing and support activities for transportation	0.66	0.68	0.69	0.74
Postal and courier activities	0.39	0.45	0.52	0.84
Accommodation and food service activities	0.88	0.81	0.75	0.75
Publishing activities	0.85	0.72	0.62	0.71
Motion picture, video and television, sound	0.46	0.41	0.37	0.81
Telecommunications	0.79	0.81	0.83	0.72
Computer programming, consultancy; information	0.37	0.23	0.14	0.73
Financial services, except insurance and pension	0.51	0.42	0.34	0.73
Insurance, reinsurance and pension funding	0.43	0.29	0.20	0.62
Auxiliary to financial and insurance activities	0.68	0.53	0.42	0.76
Real estate activities	0.75	0.66	0.57	0.78
Legal and accounting, management, consultancy	0.70	0.57	0.47	0.76
Architectural, engineering, technical testing	0.66	0.56	0.48	0.86
Scientific research and development	0.85	0.76	0.68	0.69
Advertising and market research	0.01	0.36	9.97	0.55
Other professional, scientific, veterinary activities	0.79	0.83	0.87	0.79
Administrative and support service activities	0.61	0.65	0.70	0.74
Public administration and defense	0.95	0.93	0.91	0.76
Education	0.56	0.63	0.71	0.72
Human health and social work activities	0.85	0.82	0.78	0.77
Other service activities	0.62	0.54	0.47	0.73
Undifferentiated goods- and services activities	0.04	-0.69	12.15	0.23
Activities of extraterritorial organizations	0.97	0.63	0.41	0.98

Notes: This table reproduces the main results from Table 1 for each sector in WIOD for the year 2000. See text for further details.

Table 8: Robustness: WIOD, 2014

Sector	R^2	Reg.Coeff	Var.Ratio	Sign (%)
Crop and animal production	0.55	0.55	0.54	0.71
Forestry and logging	0.94	0.88	0.82	0.66
Fishing and aquaculture	0.70	0.84	1.00	0.70
Mining and quarrying	0.49	0.50	0.51	0.77
Manufacture of food beverages, tobacco	0.64	0.58	0.52	0.67
Manufacture of textiles, apparel, leather	0.72	0.60	0.51	0.72
Manufacture of wood and cork;	0.39	0.61	0.94	0.62
Manufacture of paper and paper products	0.41	0.41	0.40	0.71
Printing and reproduction of recorded media	0.67	0.52	0.41	0.79
Manufacture of coke and refined petroleum	0.87	0.81	0.76	0.67
Manufacture of chemicals and chemical products	0.23	0.28	0.35	0.68
Manufacture of basic pharmaceutical products	0.24	0.27	0.30	0.63
Manufacture of rubber and plastic products	0.84	0.66	0.52	0.75
Manufacture of other non-metallic minerals	0.70	0.64	0.59	0.60
Manufacture of basic metals	0.63	0.63	0.63	0.65
Manufacture of fabricated metal products	0.71	0.78	0.86	0.69
Manufacture of computer, electronic and optical	0.77	0.60	0.47	0.72
Manufacture of electrical equipment	0.82	0.74	0.68	0.70
Manufacture of machinery and equipment n.e.c.	0.64	0.58	0.53	0.68
Manufacture of motor vehicles, trailers and semi-trailers	0.65	0.60	0.56	0.83
Manufacture of other transport equipment	0.58	0.51	0.44	0.79
Manufacture of furniture; other manufacturing	0.75	0.83	0.93	0.74
Repair and installation of machinery and equipment	0.84	0.77	0.70	0.96
Electricity, gas, steam and air conditioning supply	0.58	0.56	0.53	0.59
Water collection, treatment and supply	0.08	0.36	1.70	0.79
Sewerage; waste collection, disposal;	0.38	0.38	0.39	0.81
Construction	0.79	0.75	0.71	0.71
Wholesale, repair of vehicles and motorcycles	0.97	0.97	0.98	0.82
Wholesale trade, except of vehicles and motorcycles	0.40	0.48	0.58	0.70
Retail trade, except of motor vehicles and motorcycles	0.58	0.54	0.51	0.66
Land transport and transport via pipelines	0.80	0.70	0.61	0.68
Water transport	0.74	0.66	0.58	0.71
Air transport	0.48	0.52	0.57	0.69
Warehousing and support activities for transportation	0.55	0.54	0.53	0.72
Postal and courier activities	0.56	0.57	0.58	0.86
Accommodation and food service activities	0.73	0.76	0.78	0.76
Publishing activities	0.69	0.55	0.44	0.70
Motion picture, video and television, sound	0.79	0.61	0.47	0.82
Telecommunications	0.83	0.66	0.53	0.70
Computer programming, consultancy; information	0.51	0.29	0.16	0.67
Financial services, except insurance and pension	0.50	0.33	0.22	0.66
Insurance, reinsurance and pension funding	0.25	0.19	0.13	0.63
Auxiliary to financial and insurance activities	0.67	0.49	0.36	0.60
Real estate activities	0.54	0.51	0.49	0.73
Legal and accounting, management, consultancy	0.67	0.55	0.44	0.74
Architectural, engineering, technical testing	0.65	0.53	0.43	0.79
Scientific research and development	0.86	0.83	0.80	0.71
Advertising and market research	0.64	0.68	0.73	0.82
Other professional, scientific, veterinary activities	0.85	0.71	0.60	0.82
Administrative and support service activities	0.70	0.62	0.55	0.78
Public administration and defence	0.89	0.87	0.86	0.77
Education	0.69	0.59	0.50	0.69
Human health and social work activities	0.74	0.75	0.76	0.75
Other service activities	0.80	0.66	0.54	0.71
Undifferentiated goods- and services activities	0.92	0.96	1.01	1.48
Activities of extraterritorial organizations	0.98	0.64	0.42	1.26

Notes: This table reproduces the main results from Table 1 for each sector in WIOD for the year 2014. See text for further details.

Table 9: Panel Symmetric Trade Costs I

	R^2	Reg.Coeff	Var.Ratio	Sign (%)
1988	0.94	0.86	0.80	0.67
1989	0.92	0.80	0.70	0.77
1990	0.90	0.82	0.74	0.77
1991	0.90	0.82	0.75	0.76
1992	0.91	0.87	0.83	0.77
1993	0.92	0.87	0.81	0.76
1994	0.91	0.85	0.79	0.75
1995	0.87	0.81	0.75	0.75
1996	0.83	0.77	0.71	0.75
1997	0.83	0.78	0.74	0.75
1998	0.86	0.86	0.87	0.76
1999	0.88	0.86	0.85	0.73
2000	0.88	0.87	0.86	0.74
2001	0.85	0.83	0.81	0.73
2002	0.84	0.82	0.81	0.75
2003	0.79	0.79	0.79	0.74
2004	0.77	0.78	0.78	0.75
2005	0.77	0.77	0.76	0.74
2006	0.77	0.76	0.74	0.74

Notes: This table reproduces the indicators from Panel B of Table 3 for each year in our sample. The estimates are based on an underlying panel gravity estimation, where bilateral trade costs are proxied by symmetric pair fixed effects and one border variable for each year in the sample. See text for further details.

Table 10: Panel Symmetric Trade Costs II

	R^2	Reg.Coeff	Var.Ratio	Sign (%)
1988	0.96	0.92	0.88	0.71
1989	0.95	0.86	0.78	0.78
1990	0.93	0.87	0.82	0.77
1991	0.92	0.87	0.83	0.76
1992	0.93	0.93	0.93	0.76
1993	0.93	0.92	0.91	0.75
1994	0.91	0.90	0.89	0.75
1995	0.88	0.82	0.77	0.72
1996	0.83	0.78	0.74	0.75
1997	0.83	0.80	0.77	0.75
1998	0.85	0.87	0.90	0.76
1999	0.87	0.87	0.87	0.74
2000	0.87	0.88	0.89	0.75
2001	0.87	0.82	0.77	0.72
2002	0.87	0.82	0.78	0.74
2003	0.84	0.80	0.77	0.74
2004	0.83	0.79	0.76	0.75
2005	0.83	0.79	0.75	0.74
2006	0.83	0.78	0.74	0.74

Notes: This table reproduces the indicators from Panel B of Table 3 for each year in our sample. The estimates are based on three underlying panel gravity estimations (for the periods 1988-1994, 1995-2000, and 2001-2006), where bilateral trade costs are proxied by symmetric pair fixed effects and one border variable for each year in the sample. See text for further details.

Table 11: Panel Symmetric Trade Costs, Sectors

	R^2	Reg.Coeff	Var.Ratio	Sign (%)
Food	0.91	0.86	0.82	0.78
Textile	0.97	1.00	1.04	0.80
Wood	0.99	0.98	0.98	0.77
Paper	0.97	1.07	1.18	0.85
Chemicals	0.72	0.65	0.58	0.81
Minerals	0.86	0.89	0.91	0.74
Metals	0.86	0.87	0.88	0.71
Machinery	0.94	0.95	0.96	0.89

Notes: This table reproduces the indicators from Panel B of Table 3 for each sector in our sample. The estimates are based on an underlying sectoral panel gravity estimation, where bilateral trade costs are proxied by symmetric pair fixed effects and one border variable for each year in the sample. See text for further details.

Table 12: Aggregate vs. Bilateral Trade Balances: GE Effects. Estimated Trade Costs I

		Actual vs. Predicted Balances		Alternative Aggregate Trade Balances (Alternative ϕ's)					
ISO	ID	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Actual	Predicted	1.1	1.2	1.4	.9	.8	.6
CAN	1	-1,069	-599	-2,582	-4,662	-8,300	1,544	2,971	4,915
CHN	2	-1,139	-445	-3,670	-8,290	-20,253	2,933	6,202	13,631
JPN	3	-355	-290	-1,648	-3,357	-7,045	1,110	2,256	4,402
KOR	4	-258	-287	-1,294	-2,542	-5,101	724	1,517	2,944
DEU	5	-289	-265	-1,707	-3,463	-7,173	1,233	2,398	4,451
NLD	6	319	-222	-832	-1,559	-2,982	377	797	1,470
TWN	7	-225	-190	-722	-1,372	-2,647	331	723	1,402
AUS	8	164	-155	-497	-966	-2,026	145	372	815
RUS	9	-167	-105	-372	-751	-1,691	135	321	693
BRA	10	123	-81	-714	-1,482	-3,111	594	1,138	2,114
NOR	11	-12	-65	-220	-411	-806	84	188	360
GBR	12	-238	-53	-1,154	-2,417	-4,960	1,150	2,077	3,637
IDN	13	-47	-48	-234	-482	-1,056	136	290	599
ITA	14	-125	-38	-518	-1,119	-2,484	479	910	1,726
SWE	15	25	-36	-260	-525	-1,069	199	381	695
BEL	16	116	-34	-375	-771	-1,559	333	614	1,083
CHE	17	-144	-30	-323	-669	-1,387	282	526	947
IND	18	-175	-30	-523	-1,144	-2,538	511	980	1,883
AUT	19	-43	-17	-123	-256	-551	94	183	346
FIN	20	-13	-13	-125	-261	-544	108	203	374
POL	21	-7	-11	-90	-192	-433	73	142	277
CZE	22	-11	-6	-54	-115	-256	45	87	168
LTU	23	-17	-4	-16	-32	-69	8	17	34
HUN	24	9	-2	-60	-129	-276	61	114	210
ROM	25	-9	-1	-28	-63	-147	28	54	105
SVK	26	2	-1	-11	-25	-56	10	19	38
SVN	27	-1	-1	-8	-17	-37	6	12	24
EST	28	-2	-1	-6	-13	-29	5	10	18
BGR	29	-1	-1	-9	-20	-48	9	17	33
LVA	30	1	-1	-5	-11	-24	4	8	16
CYP	31	0	-0	-9	-18	-38	9	17	30
HRV	33	3	0	-8	-18	-42	10	18	34
MLT	34	5	3	-5	-13	-28	13	21	36
DNK	35	35	3	-106	-233	-492	128	229	410
PRT	36	-16	4	-29	-69	-162	42	76	142
GRC	37	20	4	-41	-94	-207	57	102	186
ESP	38	-63	8	-204	-464	-1,065	247	454	853
FRA	39	202	15	-735	-1,625	-3,526	856	1,548	2,793
TUR	40	-13	23	-112	-275	-660	184	333	629
LUX	41	365	57	-77	-210	-436	225	357	561
IRL	42	630	113	-374	-834	-1,535	672	1,038	1,508
MEX	43	73	454	-674	-1,865	-3,925	1,639	2,414	3,470

Notes: This table reproduces the main results from Table 4. However, instead of calibrated trade costs, the results are obtained with estimated trade costs that are obtained from a cross-section gravity specification specification. See main text for further details.

Table 13: Aggregate vs. Bilateral Trade Balances: GE Effects. Estimated Trade Costs II

		Actual vs. Predicted Balances		Alternative Aggregate Trade Balances (Alternative ϕ's)					
ISO	ID	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Actual	Predicted	1.1	1.2	1.4	.9	.8	.6
CAN	1	-1,069	-572	-2,988	-5,404	-9,424	2,026	3,638	5,705
AUS	2	164	-390	-1,156	-2,015	-3,566	365	897	1,783
CHN	3	-1,139	-344	-3,597	-8,282	-20,422	3,098	6,458	14,026
RUS	4	-167	-271	-1,162	-2,249	-4,401	609	1,285	2,503
KOR	5	-258	-190	-879	-1,779	-3,742	474	1,000	1,984
JPN	6	-355	-134	-1,042	-2,286	-5,270	786	1,590	3,212
DEU	7	-289	-124	-894	-1,901	-4,238	653	1,283	2,464
TWN	8	-225	-106	-332	-649	-1,358	80	210	457
NLD	9	319	-96	-345	-683	-1,453	121	273	541
BRA	10	123	-82	-844	-1,718	-3,459	751	1,398	2,497
NOR	11	-12	-72	-291	-559	-1,096	136	285	535
IDN	12	-47	-63	-390	-799	-1,653	278	559	1,087
IND	13	-175	-50	-642	-1,384	-3,001	590	1,142	2,193
ITA	14	-125	-41	-612	-1,318	-2,868	575	1,087	2,038
SWE	15	25	-29	-251	-519	-1,068	204	387	706
POL	16	-7	-21	-247	-520	-1,088	222	420	780
CHE	17	-144	-18	-215	-466	-1,028	189	358	671
AUT	18	-43	-16	-152	-320	-684	126	241	450
GBR	19	-238	-14	-609	-1,366	-3,106	628	1,166	2,169
BEL	20	116	-11	-160	-349	-779	145	273	510
FIN	21	-13	-10	-141	-296	-610	132	245	443
CZE	22	-11	-10	-128	-270	-568	118	221	409
ROM	23	-9	-7	-114	-239	-486	110	205	373
FRA	24	202	-6	-791	-1,737	-3,765	863	1,585	2,889
ESP	25	-63	-6	-469	-1,013	-2,139	512	941	1,711
LTU	26	-17	-6	-35	-69	-136	24	47	86
SVK	27	2	-3	-68	-144	-296	69	127	231
BGR	28	-1	-3	-47	-97	-194	45	84	151
SVN	29	-1	-3	-28	-58	-118	24	45	83
EST	30	-2	-3	-26	-53	-103	23	43	77
LVA	31	1	-2	-28	-58	-113	26	49	87
GRC	32	20	-1	-78	-165	-334	86	157	280
CYP	33	0	-1	-13	-27	-53	12	23	41
HRV	34	3	-1	-32	-68	-136	35	64	113
PRT	36	-16	0	-118	-250	-505	134	241	425
HUN	37	9	2	-67	-148	-311	80	146	261
MLT	38	5	4	0	-3	-10	11	18	30
DNK	39	35	5	-100	-223	-483	125	226	408
TUR	40	-13	17	-256	-571	-1,215	336	607	1,097
LUX	41	365	21	-2	-24	-68	58	95	165
IRL	42	630	25	-74	-187	-428	141	239	409
MEX	43	73	286	-1,123	-2,515	-4,783	1,788	2,699	3,847

Notes: This table reproduces the main results from Table 4. However, instead of calibrated trade costs, the results are obtained with estimated trade costs that are obtained from a panel gravity specification specification.See main text for further details.