CHAPTER 4

THE DETERMINANTS OF BILATERAL TRADE AND SPILLOVERS FROM TARIFFS
Online Annex

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Annex 1. Gravity Model, Data, and Estimation

This annex details the gravity model of bilateral exports, which Figure 7 in the main text is constructed from.

Model Specification

The model follows the state of the art empirical gravity approached which is the counterpart to a micro-founded theoretical literature based on Anderson and van Wincoop (2003), who modelled the general equilibrium effects of trade costs via an Armington-CES model, and Eaton and Eaton and Kortum (2002), who model geographic features of trade into a general equilibrium Ricardian model. The gravity representation at the aggregate level of bilateral exports has a multiplicative form:

$$\begin{aligned} X_{ijt} = \exp[\alpha + \beta_1\, ln(Y_{it}) + \beta_2 ln\left(E_{jt}\right) + \beta_3 \ln(Y_{wt}) + \\ +(\beta_4\ ln(Distance_{ij}) + \beta_5\, Language_{ij} + \beta_6\, Colony_{ij} + \beta_7\, Border_{ij} \\ + \beta_8\, FTA_{ijt}) \cdot (1 - SM_{ij}) + \beta_9\, ln(Distance_{ij}) \cdot SM_{ij} + \beta_{10}\, SM_{ij} \\ + \beta_{11}\, ln(1 + \tau_{ijt}) + \beta_{12} ln\,(MRT_{it}^{out}) \\ + \beta_{13}\, ln(MRT_{jt}^{in})\,] \cdot \eta_{ijt} \end{aligned} \quad (1)$$

where X_{ijt} are gross exports from country *i* to country *j* at time *t*. The first set of terms capture macroeconomic conditions for the exporter and importer. Domestic macroeconomic factors for the exporter (supply side) are proxied by gross output (Y_{it}), while domestic factors for the importer (demand side) are proxied by gross expenditure (intermediate and final goods) E_{jt}. Global macroeconomic factors are also controlled for using gross world output, $Y_{wt} = \sum_i Y_{it}$.

The remaining set of terms in this specification capture different effects of trade costs, which together define bilateral trade intensity. The unobservable component of bilateral trade costs is proxied by physical distance, common language, and common colonial history. The observable component includes bilateral tariffs (for goods only) τ_{ijt}, and a dummy variable for free, preferential, or regional trade agreements, FTA_{ijt}, which takes the value 1 if the two trading countries have a trade agreement and zero otherwise. The multilateral resistance terms (MRT) are also important determinants of trade intensities. The "outward" term (MRT_{it}^{out}) is an average of trading costs faced in the global market by the exporting country. Instead, the "inward" term (MRT_{jt}^{in}) captures the overall trading costs that the importing country imposes on the rest of the world.

Finding appropriate proxies for the multilateral resistance terms is one of the various numerous econometric issues that arises in empirical implementations of the gravity model (see Yotov and others, 2016, for detailed discussion). Much of the literature employs exporter and importer or exporter-time and importer-time fixed effects to capture these terms (Feenstra, 2004; Redding and Venables, 2004). This approach, however, also absorbs all time-varying country specific characteristics, including the macroeconomic factors that the chapter seeks to identify. Because these terms cannot simply be ignored in the model (Baldwin and Taglioni, 2007), they are instead proxied for using a two-step procedure to capture remoteness.

In the first step, the multilateral resistance term is initially proxied by the bilateral GDP-weighted distance between the country-pairs as in Wei (1996), Baldwin and Harrigan (2011) and Martin et al. (2008)[1] :

$$MRT_{it} = \left(\sum_j \left(\frac{Y_{jt}}{Y_{wt}} \right) \cdot Distance_{ij}^{(1-\sigma)} \right)^{\frac{1}{1-\sigma}}$$

where σ is set to 3, consistent with most empirical and theoretical literature.[2] Since the distance variable is symmetric, then for a given country the outward and inward multilateral resistance terms are equal at this stage. These first-step proxies are then used in the gravity regression, from which predicted bilateral trade costs $\hat{T}_{ijt}$ are built from the estimated coefficients on both tariffs and on the other cost components:

$$\begin{aligned} \hat{T}_{ijt} = \exp\{-[(\hat{\beta}_4\, ln(Distance_{ij}) + \hat{\beta}_5\, Language_{ij} + \hat{\beta}_6\, Colony_{ij} + \hat{\beta}_7\, Border_{ij} \\ + \hat{\beta}_8\, FTA_{ij}) \cdot (1 - SM_{ij}) + \hat{\beta}_9 ln(Distance_{ij}) \cdot SM_{ij} + \hat{\beta}_{10}\, SM_{ij} \\ + \hat{\beta}_{11} ln(1 + \tau_{ijst})]/(1-\sigma)\} \end{aligned}$$

The predicted trade costs are then used to construct the final version of the multilateral resistance terms:

$$MRT^{out}{}_{it} = \left(\sum_j \left(\frac{Y_{jt}}{Y_{wt}} \right) \cdot \hat{T}_{ijt}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

$$MRT^{in}{}_{jt} = \left(\sum_i \left(\frac{Y_{it}}{Y_{wt}} \right) \cdot \hat{T}_{jit}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

Note how countries with low world output shares have negligible effects on the multilateral resistance terms and thus on bilateral exports.

[1] Head and Mayer (2014) note that such proxies bear little resemblance to their theoretical counterparts and show that they implicitly assume that the theoretical variables that capture expenditure-weighted market potential or access (the *MRT* terms) are equal to one, while simultaneously trying to proxy for these variables. Nonetheless, the proxies are used here as the identification of macroeconomic factors of trade is key to the analysis.

[2] Results are also robust to setting $\sigma = 2$, as defined in Head and Mayer (2014).

The sample used in the estimation includes both inter- and intra-national trade, which allows the model to be theoretically consistent, among other advantages (see Yotov, Piermartini, Monteiro, and Larch, 2016). A dummy variable SM_{ijs} that takes the value of 1 for intra-national trade and zero otherwise is included in the regression and captures home bias in trade. The dummy is interacted with geographical variables to allow for different coefficient estimates on the effect of distance for inter- and intra-national trade, solving the well-known "distance puzzle" that the estimated negative impact of distance on trade has remained persistently high despite declining transportation costs (Disdier and Head, 2008).

The aggregate model is only one of the possible specifications of the gravity equation. The more frequent specification used is instead based on a sector-level estimation, where the gravity is assumed to hold at the sectoral level (see below for a description of sectoral data). The estimated coefficients are in general assumed to be the same across sector. The only exception is that all the non-tariff cost variables are interacted with a dummy (not reported for brevity) that takes the value of 1 for the service sector and zero for the non-service sectors.

The model is estimated using pseudo Poisson maximum likelihood (PPML) (Silva and Tenreyro, 2006), which allows for inclusion of observations with zero trade flows (the alternative log-linear OLS form would drop these observations). This method is especially important when estimating a gravity model at the sectoral level, because there are many sector-exporter-importer pairs with zero bilateral gross flows. The PPML method also accounts for heteroscedasticity, which is often present in trade data.

Numerous robustness exercises are conducted. In the baseline sectoral specification, the coefficients on output and expenditure are constrained to 1 ($\beta_1 = \beta_2 = 1$) and the coefficients on the multilateral resistance terms are constrained to be equal to each other ($\beta_{12} = \beta_{13}$), consistent with theoretical models (Cunat and Zymek, 2018). A first robustness check is then to run a partially unconstrained model, allowing the multilateral resistance terms to be unconstrained, then to run a fully unconstrained version of the regression. A second exercise is to compare the coefficients estimated from the sectoral regression with the ones from the regression at the aggregate level, which abstracts from some of the noise at the sector level. At the aggregate level, constrained and unconstrained versions of the model are then estimated using one of two measures of importer expenditure: gross expenditure and GDP plus imports. This latter measure is motivated purely empirically as an attempt to capture the effect of countries' involvement in global value chains, where production is carried out using a large amount of foreign inputs.[3] Third, the model is estimated at the aggregate level with country-pair-fixed effects, which control for the bilateral time-invariant trade costs. This approach also addresses the presence of omitted variables and concerns of endogeneity of trade policy variables (Baier and Bergstrand, 2007; Yotov and others, 2016). Finally, the model is estimated in

[3] Another way to look at this measure of expenditure is as the sum of final domestic absorption (consumption and investment) plus exports. Demand from the trading partner will increase not only with its final domestic absorption but also with its overall exports— if it imports to re-export to the rest of the world through a supply chain.

the cross-section at five-year horizons, to confirm that the results are consistent with theoretical gravity models that explain bilateral exports only in the cross-section.

Data

The model is estimated using the 2016 and 2018 Trade in Value Added (TiVA) databases from the OECD. The 2016 TiVA reports bilateral export and gross production data at the ISIC 3 level for 34 sectors and 63 countries from 1995-2011, and the 2018 TiVA at the ISIC 4 level for 34 sectors and 63 countries from 2005-2015. The datasets are combined by splicing the 2016 TiVA database forward from 2006 onward using the change in the share of each variable in global GDP in the 2018 TiVA database. In order to match the sectors, two sectors in each database were combined for a total of 33 sectors in the final database. The database does not report intra-national trade, which is instead constructed as the difference between gross production value and exports. At the sectoral level the constructed value of intra-national trade is negative for a small number of country-sector observations. As it is not clear whether this is a data reporting issue or whether these are sectors in which a portion of exports are in fact goods produced in other domestic sectors, these values are set to zero. The OECD input-output tables, on which the TiVA database is built, are used to construct gross expenditure at the country-sector level as the sum of the importing country's expenditure on intermediate and final goods from each of the other exporting country-sectors. In the robustness exercise where the importing country expenditure is defined as GDP plus imports, the data is taken from the IMF's WEO database. Finally, world gross production, used in both the construction of the multilateral resistance terms and as a regressor in the model is constructed as the sum of all country-sector gross output observations from the TiVA database.

The tariff data is taken from the World Bank's World Integrated Trade Solution (WITS) database, which is aggregated from the product to sector level using trade-weighted averaging. The tariff data is only available for goods, and so the value of tariffs for all service sectors is set to zero. The other trade cost variables – distance, colonial history, contiguity, common language, and free trade agreements—are from Head, Mayer, and Riess (2010) and Head and Mayer (2014) of the CEPII. In robustness exercises we also use non-tariff measures (NTMs), from the UNCTAD TRAINS database. There are many missing values for NTMs at the sector level, which are assumed to be zero.

Results

Table 1 reports results for the sectoral model that estimates equation (1) on the 5-year average panel. Column (1) is the baseline specification using the basic distance-based multilateral resistance term and, restricting the coefficient on gross output and expenditure to 1 and the coefficients on the multilateral resistance terms to be equal. Column (2) is the sample baseline constrained specification but using the predicted-cost-based multilateral resistance term—the coefficient estimates are highly robust between the two specifications. The remaining columns use the predicted-cost based multilateral resistance term. Column (3) and (4) report the sector-level robustness exercises allowing the coefficients on the multilateral resistance terms to be unconstrained and then also allowing the coefficients on output and expenditure to be unconstrained, respectively. Finally, in column (5) the specification includes non-tariff measures. The coefficient estimates are broadly in line with the existing empirical gravity literature. In particular, the impact of tariffs is estimated to have a negative and significant impact on gross bilateral exports – with an elasticity that is approximately consistent with the assumption that $\sigma = 3$ in the multilateral resistance terms.[4] Other trade costs are notably larger for trade in services than trade in goods, which is expected given that in most cases trading costs in services are larger than trading costs in goods. In the unconstrained regression, the estimated coefficients for output and expenditure are positive but smaller than 1, in partial contrast with their expected theoretical value. However, additional regressions (not reported here) confirm that the estimated coefficients increase to around 0.8 when the regression is performed only on international trade data. Because of this finding and of the appeal of the theoretical model, the constrained version is then retained as the baseline specification. Finally, controlling for NTMs decreases the estimated impact of tariffs only very minorly, suggesting that these measures have a separate, important impact on trade that differs from tariffs.

Table 2 reports the results of each period's cross section for the baseline (constrained with predicted-cost-based multilateral resistance terms) model, which are broadly in line with those in Table 1. Apart from the tariff coefficient becoming insignificant in the first period, the coefficient estimates are very stable, suggesting that estimating in the model in a panel should not bias the results in any particular direction.

Table 3 reports results for the model (constrained and unconstrained, with predicted-cost-based multilateral resistance terms) at the country level. The model is estimated for two definitions of country-level expenditure, as mentioned above. A version of the model is also estimated replacing the bilateral time-invariant trade costs with country-pair fixed effects. The results at the country level are robust to those at the sector level. The estimated coefficient on tariffs is substantially larger, remaining in line with existing literature along with the other cost variables. The results are also robust across the definitions of expenditure, and whether the coefficient estimate on the macroeconomic factors (output and expenditure) are constrained to one or left unconstrained.

A. Predicting Trade Balances

Construction

Drawing on the estimates of bilateral exports, bilateral imports are constructed using the coefficient estimates from column (2) of Table 1 and inverting the dataset to the importer perspective. This allows to construct predicted values for bilateral trade balances – at either the aggregate or the sectoral level, depending on the specification. The actual bilateral trade balances are then regressed on these predicted values to assess how well the gravity model explains

[4] See Yotov and others (2016) and Caliendo and Parro (2015) who explain that (1- σ) is equal to the coefficient on tariffs in the gravity regression, and that estimates of 3 are (on the low end, but) broadly in line with the literature.

bilateral trade (noting that it explained gross exports very well). At the aggregate level this regression is then,

$$TB_{ijt} = \alpha + \beta \widehat{TB}_{ijt} + \varepsilon_{ijt}$$

Results for the aggregate and sector-level panel models are reported in Table 4. The conclusion is that the gravity model explains the levels of trade balances less well than it explains unidirectional trade flows, consistent with the long-established observation in the literature that trade balances are more difficult to predict than exports (see Davis and Weinstein, 2002). Nonetheless, the gravity model explains well changes, rather than levels, of bilateral trade balances, as shown in the decomposition charts in the main text. Indeed, the levels of bilateral trade balances are explained much better when the gravity estimation includes country-pair fixed effects (column (4) and (7), Table 5).[5]

The baseline specification for the analysis of bilateral trade balance is the sectoral gravity regression, with the subscript s representing an arbitrary sector. Because the gravity model is a multiplicative, the change over time in the trade balance at the sectoral level can be approximated as [6]

$$\Delta TB_{isjt} \approx \Delta \ln\left(X_{ijst}\right) \cdot X_{ijst-1} - \Delta \ln\left(X_{jist}\right) \cdot X_{jist-1}$$

Using estimates from Table 1, the right-hand side of the above approximation is constructed as the predicted values of each time-varying regressor, normalized by initial bilateral exports and imports. [7,8] The approximate change in in the bilateral trade balance for sector s is then

$$\begin{aligned}\Delta TB_{ijst} \approx \Big(&\hat{\beta}_1 \Delta \ln(Y_{ist}) + \hat{\beta}_2 \Delta \ln\left(E_{jst}\right) + \hat{\beta}_3 \Delta \ln(Y_{wt}) + \hat{\beta}_8 \Delta FTA_{ijt} + \hat{\beta}_{11} \Delta \ln\left(1 + \tau_{ijst}\right) \\ &+ \hat{\beta}_{12} \Delta \ln\left(MRT_{ist}^{in}\right) + \hat{\beta}_{13} \Delta \ln\left(MRT_{jst}^{out}\right) + \Delta \ln\left(\eta_{ijst}\right)\Big) \cdot X_{ijst-1} \\ &- \Big(\hat{\beta}_1 \Delta \ln\left(Y_{jst}\right) \\ &+ \hat{\beta}_2 \Delta \ln(E_{ist}) + \hat{\beta}_3 \Delta \ln(Y_{wt}) + \hat{\beta}_8 \Delta FTA_{jit} + \hat{\beta}_{11} \Delta \ln\left(1 + \tau_{jist}\right) \\ &+ \hat{\beta}_{12} \Delta \ln\left(MRT_{jst}^{out}\right) + \hat{\beta}_{13} \Delta \ln\left(MRT_{ist}^{in}\right) + \Delta \ln\left(\eta_{jist}\right)\Big) \cdot X_{jist-1}\end{aligned}$$

The terms above can be grouped to create a set of sectoral contributions. For instance, sectoral output and expenditure for the exporting country can be combined to create a domestic "net

[5] The trade balance fit also improves when the estimation is performed only for the largest bilateral trade balance pairs–those that make up the majority of global trade.

[6] The log-difference of the regressor is approximately equal to the growth rate for relatively small changes (less than 10 percent). About 90 percent of the observed changes in the sample are within this rule-of-thumb.

[7] Initial, in this context, refers to the t-1 period in the difference calculation. This improves the approximation considerably relative to normalizing by initial (time 0) exports or imports, as it corrects for a portion of the approximation error in each period. Also, initial exports and imports are actual values, not predicted ones – this is also important in improving the model fit.

[8] The purpose of normalizing is to put each contribution in level (dollar) terms, which then allows each component to be added together and to equal the (approximated) trade balance in levels – i.e. as defined in the first line in the above equation.

supply" term given by $\hat{\beta}_1 \Delta \ln(Y_{ist}) \cdot X_{ijst-1} - \hat{\beta}_2 \Delta \ln(E_{ist}) \cdot X_{jist-1}$. Similarly, combining expenditure and supply of the importing country yields a "net demand" contribution to the sectoral bilateral trade balance. Similar contributions can be calculated for all other variables as the difference between the export and import predicted values. As an additional step, it is possible to highlight explicitly the role of sectoral specialization. This is done by expressing sectoral supply and demand (Y_{ist} and E_{jst}) as the product of aggregate supply and demand (Y_{it} and E_{jt}) times the corresponding sectoral share (s^Y_{ist} and s^E_{jst}), namely: $Y_{ist} = s^Y_{ist} \cdot Y_{it}$ and $E_{jst} = s^E_{jst} E_{jt}$.

Finally, each of these sectoral contributions are summed up across sectors to obtain aggregate contributions:

$$\Delta TB_{NET\ SUPPLY_i} = \Sigma_s\left[\Delta \ln(Y_{it}) \cdot \hat{\beta}_1 \cdot X_{ijst-1} - \Delta \ln(E_{it}) \cdot \hat{\beta}_2 \cdot X_{jist-1}\right]$$

$$\Delta TB_{NET\ DEMAND_i} = \Sigma_s\left[\Delta \ln\left(E_{jt}\right) \cdot \hat{\beta}_2 \cdot X_{ijst-1} - \Delta \ln\left(Y_{jt}\right) \cdot \hat{\beta}_1 \cdot X_{jist-1}\right]$$

$$\Delta TB_{WORLD\ OUTPUT} = \Sigma_s\left[\hat{\beta}_3 \cdot X_{ijst-1} - \hat{\beta}_3 \cdot X_{jist-1}\right] \cdot \Delta \ln(Y_{wt})$$

$$\Delta TB_{MULTILATERAL\ COSTS} = \Sigma_s\left[\Delta \ln(MRT^{in}_{ist}) \cdot \hat{\beta}_{12} \cdot X_{ijst-1} - \Delta \ln(MRT^{in}_{ist}) \cdot \hat{\beta}_{12}) \cdot X_{jist-1}\right] + \Sigma_s\left[\ln\left(MRT^{out}_{jst}\right) \cdot \hat{\beta}_{13} \cdot X_{ijst-1} - \Delta \ln\left(MRT^{out}_{jst}\right) \cdot \hat{\beta}_{13}\, X_{jist-1}\right]$$

$$\Delta TB_{BILATERAL\ COSTS} = \sum_s[\Delta \ln\left(1 + \tau_{ijst}\right) \cdot \hat{\beta}_{11} \cdot X_{ijst-1} - \Delta \ln\left(1 + \tau_{jist}\right) \cdot \hat{\beta}_{11} \cdot X_{jist-1}] + \sum_s[\Delta \mathrm{FTA_{ijst}} \cdot \hat{\beta}_8 \cdot X_{ijst-1} - \Delta \mathrm{FTA_{jist}} \cdot \hat{\beta}_8 \cdot X_{jist-1}]$$

$$\Delta TB_{SECTORAL\ COMP_i} = \Sigma_s\left[\Delta \ln(s^Y_{ist}) \cdot \hat{\beta}_1 - \Delta \ln(s^E_{ist}) \cdot \hat{\beta}_2\right] \cdot X_{ijst-1} - \Sigma_s\left[\Delta \ln\left(s^Y_{jst}\right) \cdot \hat{\beta}_1 - \Delta \ln\left(s^E_{jst}\right) \cdot \hat{\beta}_2\right] \cdot X_{jist-1}$$

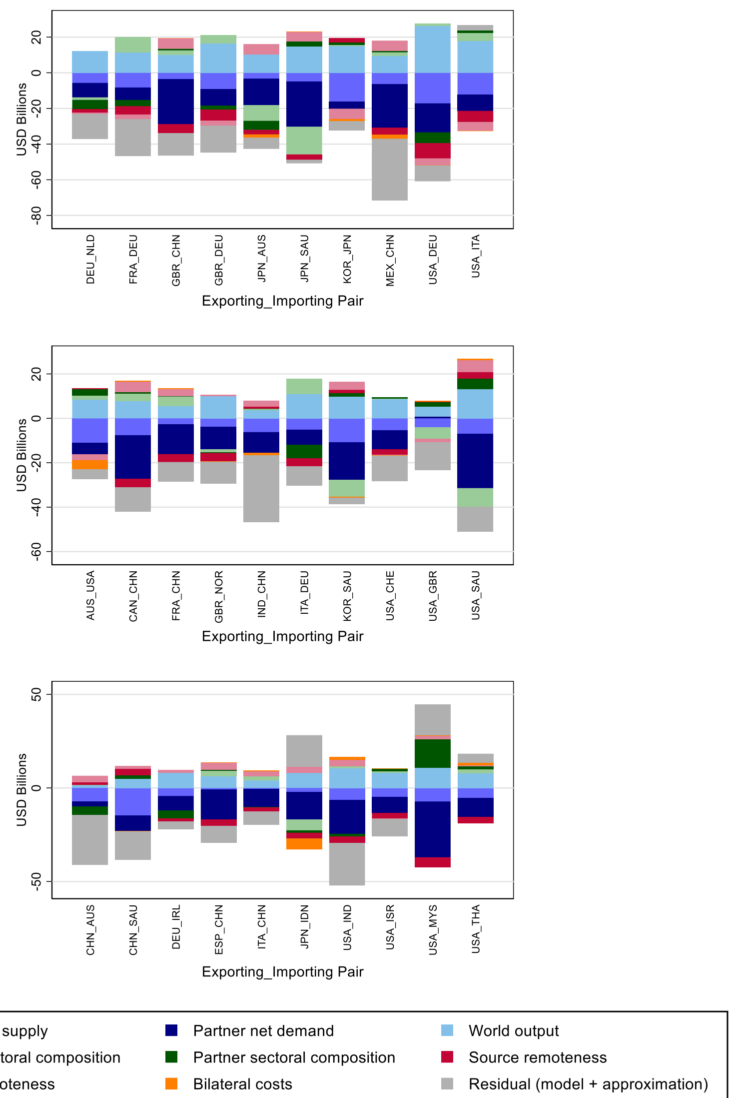
$$\Delta TB_{SECTORAL\ COMP_j} = \Sigma_s\left[\Delta \ln\left(s^E_{jst}\right) \cdot \hat{\beta}_2 - \Delta \ln\left(s^Y_{jst}\right) \cdot \hat{\beta}_1\right] \cdot X_{ijst-1} - \Sigma_s\left[\Delta \ln(s^E_{ist}) \cdot \hat{\beta}_2 - \Delta \ln(s^Y_{ist}) \cdot \hat{\beta}_1\right] \cdot X_{jist-1}$$

Results

Figure A1 provides the trade balance contribution charts for the 30 largest (positive) changes in bilateral trade balance in the world since 1995, excluding those presented in the main text. Figure A2 plots the contribution charts for the sectoral model with NTMs and Figure A3 the country level model with gross expenditure.[9] The non-tariff measures contribute a negligibly to the bilateral trade balances for most country pairs, consistent with the discussion in the main text that domestic and foreign macroeconomic factors are most important in explaining bilateral trade balances.

[9] Results for the country level model with domestic absorption plus exports are similar, and not reported here.

Figure A1. Contributions to Changes in Bilateral Trade Balance Since 1995, Sector Level, Largest Bilateral Trade Balances[1]



[1] Note that these are the largest positive bilateral trade balances – the reverse pair would have inverted contribution charts, as can be seen in the case of the US-China and China-US, or US-Germany and Germany-US in the main text.

Figure A2. Contributions to Changes in Bilateral Trade Balance Since 1995, Sector Level with NTMs

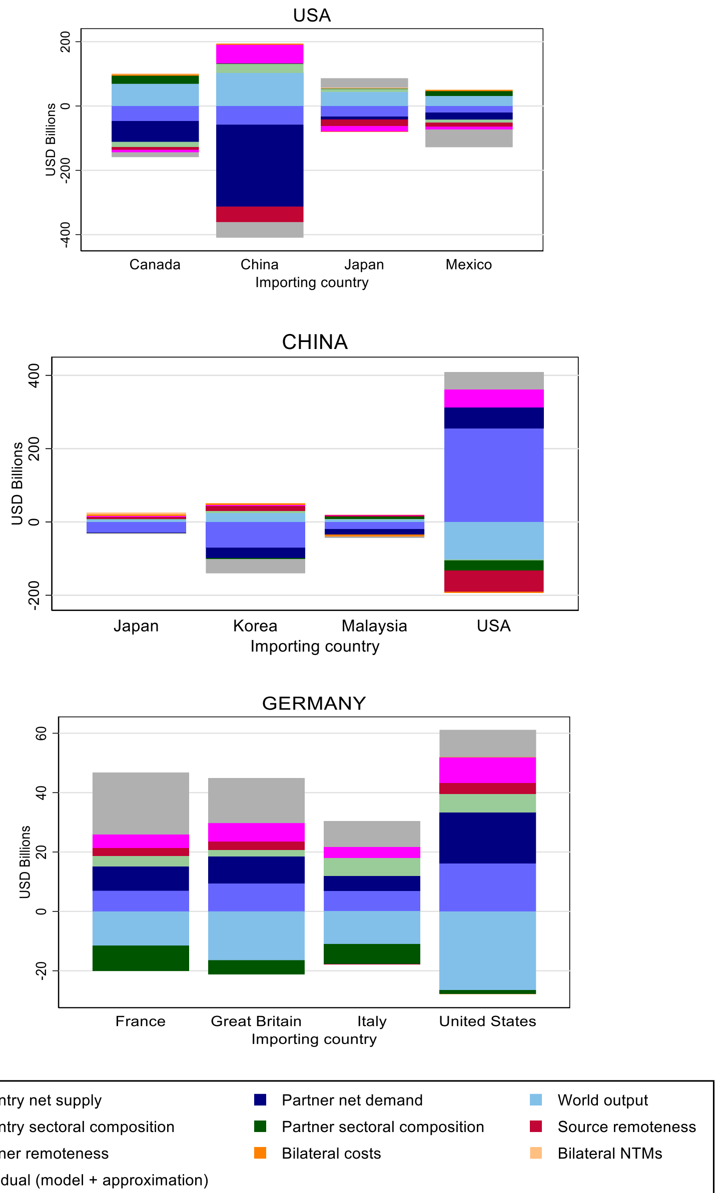


Figure A3. Contributions to Changes in Bilateral Trade Balance Since 1995, Country-Level

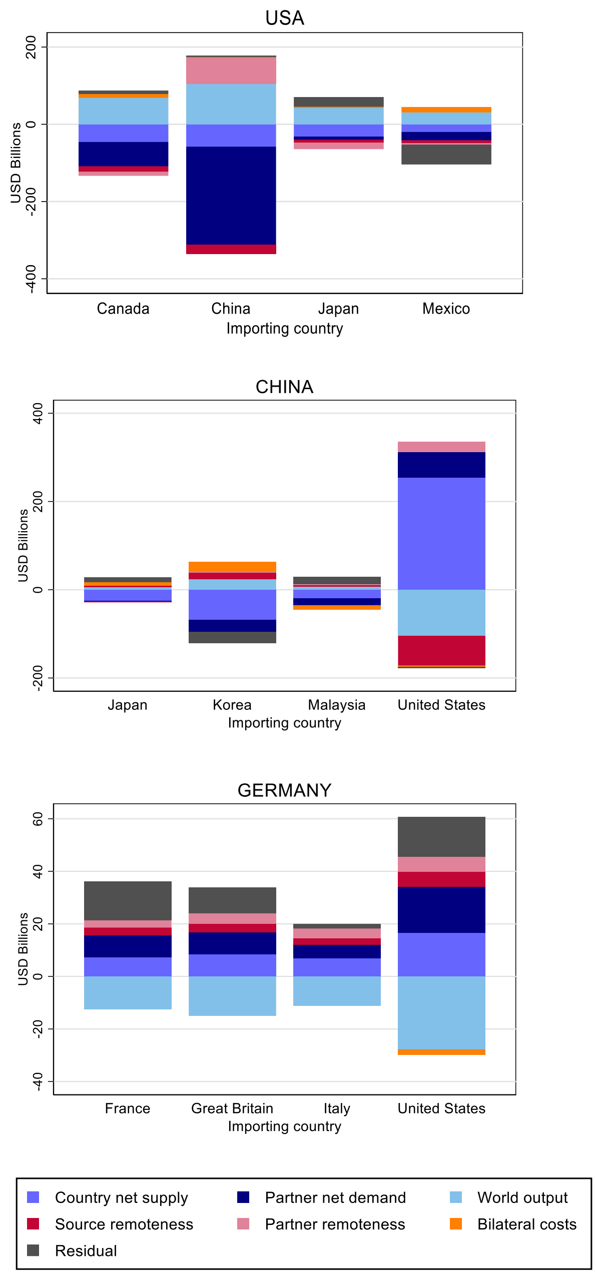


Table 1. Gravity Model: Sector Level, 5-Year Average Panel					
	(1)	(2)	(3)	(4)	(5)
Dependent Variable			*Gross bilateral exports*		
Model	Constrained, MRT-distance	Constrained, MRT-cost	Partially constrained	Unconstrained	Constrained, NTM
LN(Distance_ij)*(1-SM_ij)*(Non-Service)	-1.081***	-0.933***	-0.934***	-0.502***	-0.935***
	(0.0607)	(0.0536)	(0.0515)	(0.0656)	(0.0538)
Border_ij*(1-SM_ij)*(Non-Service)	-0.353**	-0.351**	-0.335**	0.639***	-0.359**
	(0.152)	(0.161)	(0.161)	(0.172)	(0.163)
Langauge_ij*(1-SM_ij)*(Non-Service)	0.0524	-0.106	-0.104	0.315***	-0.114
	(0.172)	(0.207)	(0.205)	(0.118)	(0.209)
Colony_ij*(1-SM_ij)*(Non-Service)	0.908**	1.076***	1.087***	0.0787	1.082***
	(0.393)	(0.417)	(0.401)	(0.167)	(0.418)
FTA_ijst*(1-SM_ij)*(Non-Service)	0.552***	0.596***	0.584***	0.138	0.599***
	(0.108)	(0.103)	(0.0977)	(0.127)	(0.103)
LN(Distance_ij)*SM_ij*(Non-Service)	-1.828***	-1.746***	-1.747***	-0.399***	-1.748***
	(0.0888)	(0.0567)	(0.0566)	(0.0785)	(0.0564)
LN(Distance_ij)*(1-SM_ij)*(Service)	-1.176***	-1.045***	-1.049***	-0.614***	-1.046***
	(0.0600)	(0.0543)	(0.0524)	(0.0663)	(0.0544)
Border_ij*(1-SM_ij)*(Service)	-0.833***	-1.072***	-1.064***	0.136	-1.073***
	(0.215)	(0.273)	(0.278)	(0.152)	(0.273)
Langauge_ij*(1-SM_ij)*(Service)	0.373**	0.264	0.260	0.615***	0.264
	(0.173)	(0.203)	(0.207)	(0.101)	(0.203)
Colony_ij*(1-SM_ij)*(Service)	1.949***	2.216***	2.177***	0.714***	2.216***
	(0.303)	(0.328)	(0.317)	(0.189)	(0.328)
FTA_ijt*(1-SM_ij)*(Service)	0.150	0.177*	0.188*	-0.207*	0.176*
	(0.106)	(0.102)	(0.0988)	(0.122)	(0.102)
LN(Distance_ij)*SM_ij*(Service)	-1.818***	-1.735***	-1.736***	-0.388***	-1.736***
	(0.0928)	(0.0581)	(0.0580)	(0.0784)	(0.0576)
LN(1+Tariff_ijst)	-1.918***	-1.769***	-2.260***	-1.863***	-1.834***
	(0.410)	(0.397)	(0.409)	(0.411)	(0.412)
LN(MRT_Distance_ist)	0.932***				
	(0.0426)				
LN(MRT_Distance_jst)	0.932***				
	(0.0426)				
LN(World Gross Output_T)	-0.952***	-1.005***	-1.006***	-0.262***	-1.011***
	(0.0585)	(0.0273)	(0.0273)	(0.0467)	(0.0270)
LN(Gross Output_ist)	1	1	1	0.680***	1
	(0)	(0)	(0)	(0.0226)	(0)
LN(Gross Expendisture_jst)	1	1	1	0.581***	1
	(0)	(0)	(0)	(0.0330)	(0)
SM_ij	6.665***	7.471***	7.475***	3.149***	7.468***
	(0.625)	(0.532)	(0.513)	(0.677)	(0.528)
LN(MRT_cost_ist)		1.020***	0.749***	0.0720	1.021***
		(0.0184)	(0.0619)	(0.0576)	(0.0184)
LN(MRT_cost_jst)		1.020***	1.293***	0.415***	1.021***
		(0.0184)	(0.0623)	(0.0674)	(0.0184)
Constant	-6.788***	-1.436***	-1.432***	-1.800***	-1.363**
	(0.920)	(0.543)	(0.528)	(0.570)	(0.530)
Observations	475,567	474,933	474,933	474,933	474,933
R-squared	0.947	0.962	0.962	0.984	0.963

Clustered (country-pair) standard errors in parenthese
*** p<0.01, ** p<0.05, * p<0.1

Table 2. Gravity Model: Sector Level, Cross-Section

	(1)	(2)	(3)	(4)	(5)
Dependent variable			*Gross bilateral exports*		
Model			Constrained		
	1995	2000	2005	2010	2015
LN(Distance_ij)*(1-SM_ij)*(Non-Service)	-0.850***	-0.780***	-0.922***	-0.935***	-0.862***
	(0.0682)	(0.0741)	(0.0610)	(0.0567)	(0.0670)
Border_ij*(1-SM_ij)*(Non-Service)	-0.281**	-0.332**	-0.288*	-0.367**	-0.558**
	(0.124)	(0.148)	(0.157)	(0.179)	(0.255)
Langauge_ij*(1-SM_ij)*(Non-Service)	-0.0982	-0.123	-0.281	-0.0772	-0.0228
	(0.221)	(0.185)	(0.218)	(0.216)	(0.227)
Colony_ij*(1-SM_ij)*(Non-Service)	1.642***	1.450**	1.422***	1.015**	1.024**
	(0.476)	(0.572)	(0.413)	(0.475)	(0.408)
FTA_ijst*(1-SM_ij)*(Non-Service)	0.777***	0.667***	0.377***	0.499***	0.541***
	(0.124)	(0.150)	(0.119)	(0.114)	(0.142)
LN(Distance_ij)*SM_ij*(Non-Service)	-1.738***	-1.759***	-1.773***	-1.703***	-1.793***
	(0.0670)	(0.0660)	(0.0669)	(0.0565)	(0.0390)
LN(Distance_ij)*(1-SM_ij)*(Service)	-0.945***	-0.900***	-1.040***	-1.047***	-0.948***
	(0.0671)	(0.0750)	(0.0617)	(0.0571)	(0.0668)
Border_ij*(1-SM_ij)*(Service)	-0.721***	-0.885***	-1.008***	-1.180***	-1.145***
	(0.231)	(0.260)	(0.278)	(0.287)	(0.304)
Langauge_ij*(1-SM_ij)*(Service)	0.00535	0.0849	0.112	0.293	0.274
	(0.226)	(0.204)	(0.214)	(0.199)	(0.212)
Colony_ij*(1-SM_ij)*(Service)	2.068***	2.388***	2.232***	2.376***	2.237***
	(0.381)	(0.360)	(0.328)	(0.348)	(0.424)
FTA_ijt*(1-SM_ij)*(Service)	0.124	0.182	0.0111	0.170	0.458***
	(0.140)	(0.157)	(0.125)	(0.111)	(0.122)
LN(Distance_ij)*SM_ij*(Service)	-1.741***	-1.757***	-1.768***	-1.689***	-1.769***
	(0.0665)	(0.0649)	(0.0663)	(0.0585)	(0.0424)
LN(1+Tariff_ijst)	-0.0246	-2.900***	-3.789***	-1.951***	-1.440***
	(0.406)	(0.674)	(0.544)	(0.598)	(0.479)
LN(MRT_cost_ist)	1.008***	1.007***	1.033***	1.012***	1.005***
	(0.0173)	(0.0219)	(0.0183)	(0.0186)	(0.0179)
LN(MRT_cost_jst)	1.008***	1.007***	1.033***	1.012***	1.005***
	(0.0173)	(0.0219)	(0.0183)	(0.0186)	(0.0179)
LN(Gross Output_ist)	1	1	1	1	1
	(0)	(0)	(0)	(0)	(0)
LN(Gross Expendisture_jst)	1	1	1	1	1
	(0)	(0)	(0)	(0)	(0)
SM_ij	8.235***	8.533***	7.446***	7.118***	8.430***
	(0.647)	(0.713)	(0.615)	(0.558)	(0.617)
Constant	-12.57***	-12.68***	-13.01***	-13.12***	-13.21***
	(0.561)	(0.648)	(0.541)	(0.509)	(0.600)
R-Squared	0.964	0.964	0.967	0.959	0.969
Observations	87,436	58,414	68,353	81,076	62,373

Clustered (country-pair) standard errors in parenthese
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Gravity Model: Country Level, 5-year Average Panel

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Gross bilateral exports						
Model	Constrained Model				Unconstrained Model		
LN(DISTANCE_ij)*(1-SM_ij)	-1.077***	-0.960***	-0.928***		-0.520***	-0.508***	
	(0.0738)	(0.0598)	(0.0626)		(0.0674)	(0.0683)	
CONTIG_ij*(1-SM_ij)	-0.455***	-0.542***	-0.488***		0.488***	0.503***	
	(0.153)	(0.180)	(0.178)		(0.157)	(0.155)	
LANGUAGE_ij*(1-SM_ij)	0.0933	-0.0794	-0.0703		0.343***	0.337***	
	(0.175)	(0.220)	(0.217)		(0.0936)	(0.0956)	
COLONY_ij*(1-SM_ij)	1.499***	1.710***	1.790***		0.411***	0.486***	
	(0.326)	(0.376)	(0.338)		(0.152)	(0.148)	
FTA_ijt*(1-SM_ij)	0.273***	0.287***	0.261**	0.125***	-0.0768	-0.0842	0.0388
	(0.105)	(0.108)	(0.107)	(0.0434)	(0.126)	(0.128)	(0.0342)
LN(DISTANCE_ij)*SM_ij	-1.799***	-1.751***	-1.680***		-0.419***	-0.404***	
	(0.110)	(0.0699)	(0.0919)		(0.0879)	(0.0746)	
LN(1+TARIFF_ijt)	-5.397***	-5.359***	-4.776***	-4.207***	-4.562***	-4.180***	-4.198***
	(1.189)	(1.138)	(1.136)	(0.538)	(1.050)	(1.039)	(0.466)
LN(MRT_Distance_it)	0.919***						
	(0.0694)						
LN(MRT_Distance_jt)	0.919***						
	(0.0694)						
LN(WORLD SUPPLY_t)	-0.965***	-1.027***	-1.012***	-1.075***	-0.293***	-0.302***	-0.0817**
	(0.0679)	(0.0247)	(0.0170)	(0.0311)	(0.0498)	(0.0483)	(0.0382)
LN(SUPPLY_it)	1	1	1	1	0.625***	0.637***	0.897***
	(0)	(0)	(0)	(0)	(0.0260)	(0.0238)	(0.0808)
LN(Gross Expenditure_jt)	1	1		1	0.655***		0.164*
	(0)	(0)		(0)	(0.0294)		(0.0891)
SM_ij	6.722***	7.554***	7.431***		3.400***	3.431***	0.0402
	(0.629)	(0.566)	(0.632)		(0.681)	(0.686)	(0.243)
LN(MRT_cost_it)		1.067***	1.041***	1.082***	0.182***	0.185***	0.812***
		(0.0332)	(0.0430)	(0.0997)	(0.0615)	(0.0586)	(0.194)
LN(MRT_cost_jt)		1.067***	1.041***	1.207***	0.354***	0.352***	-0.759***
		(0.0332)	(0.0430)	(0.117)	(0.0679)	(0.0657)	(0.220)
LN(DEMAND_jt) final domestic absorption + exports			1			0.661***	
			(0)			(0.0339)	
Constant	-6.856***	-1.247**	-1.094**		-1.896***	-1.774***	
	(1.012)	(0.557)	(0.536)		(0.572)	(0.599)	
Observations	15,560	15,560	15,560	15,552	15,560	15,560	15,554
R-squared	0.969	0.986	0.966	0.9993	0.996	0.986	1.000
Country -pair FE	NO	NO	NO	YES	NO	NO	YES

Clustered (country-pair) standard errors in parenthese
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Trade Balance Fit: Sector Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable	*Actual Bilateral Trade Balance*									
	5-Year average panel					*Cross-Section*				
Model	Constrained, MRT-distance	Constrained, MRT-cost	Partially constrained	Unconstrained	Constrained, NTM	Constrained				
						1995	2000	2005	2010	2015
Predicted Bilateral Trade Balance	0.938***	1.053***	1.065***	-0.0945	1.056***	1.260***	0.824***	1.099***	0.863**	1.851***
	(0.244)	(0.214)	(0.216)	(0.235)	(0.217)	(0.127)	(0.131)	(0.249)	(0.364)	(0.497)
Observations	15,876	15,876	15,876	15,876	15,876	3,969	3,945	3,949	3,967	3,961
R-squared	0.235	0.288	0.269	0.001	0.295	0.158	0.370	0.404	0.179	0.380
R-square, subsample of largest bilateral balances	0.330	0.357	0.424	0.003	0.376	0.222	0.496	0.535	0.200	0.522

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Trade Balance Fit: Country Level, 5-year Average Panel

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable	Actual Trade Balance						
Predicted trade balance, constrained model with distance-MRT	0.799***						
Demand as gross expenditure	(0.207)						
Predicted trade balance, constrained model with cost-MRT		0.972***					
Demand as gross expenditure		(0.186)					
Predicted trade balance, constrained model with cost-MRT			0.685***				
Demand as final domestic absorption + exports			(0.233)				
Predicted trade balance, constrained model with country-pair FE				1.001***			
Demand as gross expenditure				(0.0286)			
Predicted trade balance, unconstrained model with cost-MRT					2.287***		
Demand as gross expenditure					(0.304)		
Predicted trade balance, unconstrained model with cost-MRT						1.920***	
Demand as final domestic absorption + exports						(0.500)	
Predicted trade balance, unconstrained model with country-pair FE							0.988***
Demand as gross expenditure							(0.0343)
Observations	15,282	15,282	15,282	15,282	15,282	15,282	15,282
R-squared	0.260	0.314	0.166	0.931	0.286	0.167	0.921
R-square, subsample of largest bilateral balances	0.429	0.449	0.229	0.953	0.454	0.265	0.939

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Annex 2. Derivation of Relation Between Bilateral and Aggregate Trade Balances

This appendix provides an overview of the main components of the gravity equation and derives the relation between bilateral and aggregate trade balances that motivates Sections III and IV.

The system of equations of a typical gravity framework expresses nominal exports X_{ij} from country i to j as

$$X_{ij} = \frac{Y_i E_j}{Y_w} \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma}$$

where Y_i and Y_w are, respectively, production in country i and for the world and E_j is total spending of country j. Depending on the specific version of the gravity equation, output and spending are proxied in various ways. The parameter σ provides the aggregate trade elasticity.

The multilateral resistance terms (MRTs) are important elements of theoretically based gravity equations. The outward MRT (Π_i) is an average of all the tariffs faced in the global market by the exporting country. Instead, the inward MRT (P_j) captures the overall tariff that the importing country imposes on the rest of the world. More precisely,

$$\Pi_i = \left[\sum\nolimits_j \theta_j \left(\frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

$$\mathrm{P}_j = \left[\sum\nolimits_i \theta_i \left(\frac{\tau_{ij}}{\Pi_i} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

The coefficient $\theta_i = y_i / y_w$ represents the share of country i's nominal output in world's output.[10] As noted elsewhere, in empirical applications MRTs are usually accounted for using country fixed effects. However, the regression strategy followed in the chapter is to avoid fixed effect and to control directly for the role of MRTs using proxies that have been proposed in the literature. Also, in the short--term output shares are fairly stable and unaffected by changes in trade costs.[11] Therefore, in the short-term changes in trade intensities are driven almost entirely by changes in the constellation of bilateral trade costs.

[10] This representation employs the approximations that countries' output shares in world output are close to the countries' spending shares in world spending. This relation holds exactly only when each country's aggregate trade balance is zero. However, the approximation error is small even for empirically relevant levels of aggregate imbalances.

[11] For more details, see Yotov et al. (2016).

Under some extra assumptions, the equation above can be used to derive an explicit relation between bilateral and aggregate trade balances (TB). Consider a version of the gravity equation where Y is proxied by GDP and spending E by domestic absorption

$$E_j = Y_j - TB_j$$

Under the assumption that $\tau_{ij} = \tau_{ji}$, i.e. trade cost are symmetric, it follows that $\Pi_i = \mathrm{P}_i$. The gravity equation can then be rewritten as,

$$\frac{X_{ij}}{Y_i Y_j / Y_W} = m_{ij}\left(1 - \frac{TB_j}{\mathrm{Y}_j}\right)$$

The term m is a *trade intensity* (sometimes called *trade bias*) and is a function of bilateral trade costs and the multilateral resistance terms Estimates of bilateral trade intensity can be obtained by substituting the predicted value $\hat{X}_{ij}$of bilateral exports from the gravity equation into the relation above.[12]

Under the assumption of symmetric trade costs, trade intensities turn out to be symmetric as well, i.e. $m_{ij} = m_{ji}$. This property allows to write the scaled bilateral trade balance between the two countries as[13]

$$\frac{TB_{ij}}{Y_i Y_j / Y_W} = \frac{X_{ij} - X_{ji}}{Y_i Y_j / Y_W} = m_{ij}\left(\frac{TB_i}{Y_i} - \frac{TB_j}{Y_j}\right)$$

Any trade balance-to-GDP ratio on the right-hand side of the equation above can be decomposed into its EBA determinants. The first column of Table 6 reports the regression results for such decomposition while, for comparison purposes, the second column provides the corresponding estimates for the traditional current account regression. The points estimates are broadly consistent across the two regressions, and the statistical fit is almost identical.

[12] This is how trade intensities in Figure 2 in the main text are obtained.

[13] This relation is used in Box 2 to calculate an average trade intensity between the United States and China. Specifically, a time series between 1997 and 2014 for the trade intensity is first derived, as an unobservable residual, by taking the ratio between the left-hand side of the equation and the difference of the aggregate trade balance-to-GDP ratios. The average value over the period is then calculated.

Table 6. Trade balance and current account EBA regressions

	(1) TB/GDP	(2) CA/GDP
L.Output per worker, relative to top 3 economies	0.066***	0.023
	(0.025)	(0.020)
L.Relative output per worker*K openness	0.043*	0.041*
	(0.026)	(0.021)
Oil and Natural Gas Trade Balance * resource temporariness #	0.259**	0.310***
	(0.108)	(0.089)
GDP growth, forecast in 5 years #	-0.309***	-0.302***
	(0.117)	(0.104)
L.Public Health Spending/GDP #	0.201	-0.399***
	(0.160)	(0.134)
Institutional/Political Environment (ICGR-12)#	-0.052**	-0.047**
	(0.023)	(0.019)
L. NFA/Y	-0.013*	0.023***
	(0.007)	(0.006)
L. NFA/Y*(dummy if NFA/Y < -60%)	0.038***	-0.006
	(0.014)	(0.012)
L.demeaned VIX*K openness	-0.001	0.020
	(0.016)	(0.015)
L.demeaned VIX*K openness*share in world reserves	0.058	0.002
	(0.078)	(0.067)
Own currency's share in world reserves	-0.040***	-0.030***
	(0.015)	(0.012)
(Delta Reserves)/GDP* K controls, instrumented #	0.783***	0.754***
	(0.259)	(0.236)
Output Gap #	-0.382***	-0.356***
	(0.035)	(0.032)
Commodity ToTgap*Trade Openness	0.143***	0.161***
	(0.038)	(0.036)
Detrended Private Credit/GDP #	-0.121***	-0.104***
	(0.015)	(0.013)
Cyclically adjusted Fiscal Balance, instrumented #	0.605***	0.329***
	(0.114)	(0.087)
Prime Savers Share #	0.068	0.138**
	(0.071)	(0.056)
Life Expectancy at Prime Age #	-0.004**	-0.005***
	(0.002)	(0.001)
Life Expectancy at Prime Age # * Future OADR	0.001	0.013***
	(0.006)	(0.005)
Population Growth #	-1.143**	-0.692*
	(0.487)	(0.369)
Old-age Dependency Ratio #	-0.147***	-0.069
	(0.053)	(0.043)
Constant	-0.008**	-0.009***
	(0.004)	(0.003)
Observations	1,376	1,367
R-squared	0.300	0.327

Source: IMF staff calculations.
Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. The regression controls for the presence of AR(1) autocorrelation within panels and heteroskedasticity across panels.

Annex 3. Tariff Spillovers: Technical and Data Appendices

This Appendix provides technical details for Section V. It highlights the links between the exercise presented in this chapter and the existing literature, explains in more detail how the different tariff measures are constructed and integrated into the regression model and shows a more complete set of results, including robustness checks.

A. Existing Literature

The question of the empirical effects of tariffs on economic outcome variables has been subject of a vast existing literature. For example, Amiti and Konings (2007) and Topalova and Khandelwal (2010) have used firm level data to distinguish the productivity effects of tariffs on firms output (output tariff) from the tariffs on their inputs (input tariff) within narrow geographical and temporal windows. Ahn, Dabla-Norris, Duval, Hu and Njie (2016) perform a similar exercise with an international sample at the industry level. Finally, Furceri, Hannan, Ostry and Rose (2018) distinguish input and output tariffs in a broad sample, focusing more on the short-term dynamics and the timing of the change in the trade policy. Results generally show that while both input- and output tariffs have negative effects, e.g. on productivity, the former tends to be quantitatively more important.

The exercise described here extends the existing literature by constructing a framework that is more explicitly tailored to look at international tariffs spillovers, both horizontally, as well as up and down the value chain. The exercise follows the literature by calculating both "upstream tariffs", which capture the cumulative tariff on inputs used, and measures of "domestic protection", aimed at making imported goods relatively more expensive than their domestically produced equivalents. These measures are complemented by two additional ones that capture, respectively, the cumulative tariff directly or indirectly faced by exports of a sector ("downstream tariffs") and the weighted average tariff faced by all other countries' exports in the given sector ("diversion tariff").

B. Calculation of Tariff Measures

The different tariff measures are generally constructed as weighted averages across partners. Weights used for the aggregation (indicated with a bar on the corresponding variable in the equations below) are generally trade or input shares averaged over the entire sample. Given the significant change in the trading relationships over the sample period, using averages is preferred to using weights at time zero. The calculation of upstream and downstream tariffs, which relies heavily on Rouzet & Miroudot (2013), uses the international input-output matrices. For matrix invertibility purposes, the household sectors are omitted.

The matrix A indicates the global input-output matrix for a given year, with a_{ijt} the amount of inputs used by country-industry *i* supplied by country-industry *j* at time t. T is the global tariff matrix, with T_{ij} the tariff imposed by *i* on *j*[14]. X and M are the export and import matrices with

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dimensions CS × C (where C and S are respectively the number of countries and sectors). The vector e has dimension 1 × CS. Subscripts *h*, *s* and *d* are home, source and destination country-sector respectively.

Upstream: Captures the cumulative effects of tariffs on the cost of inputs, including the tariff directly imposed on imported inputs as well tariffs imposed on indirect suppliers. It can be thought of as a supply shock.

$$T_{h,t}^{up} = \sum_{s} \bar{a}_{h,s,0} T_{h,s,t} \; + \sum_{s}\sum_{k} \bar{a}_{h,s,0}\, \bar{a}_{s,k,0}\, T_{s,k,t} + \sum_{s}\sum_{k}\sum_{j} \bar{a}_{h,s,0}\, \bar{a}_{s,k,0}\, \bar{a}_{k,j,0}\, T_{k,j,t} \dots$$

$$T_{h,t}^{up} = (\, e^{up}\, B^{up}\, (I - \bar{A})^{-1}\,)'$$

$$\text{where} \quad e^{up} = ones_{1xCS} \quad \text{and} \quad B^{up} = \bar{A} \circ T$$

Downstream: Captures the cumulative tariff that the output of a given sector faces downstream in the value chain. This includes the tariff that it faces when exporting directly as well as when value added is exported indirectly, for example when produced intermediates are exported to third country-sector.

$$T_{h,t}^{down} = \sum_{p} \bar{a}_{p,h} T_{p,h,t} + \sum_{p}\sum_{m} \bar{a}_{p,h} \bar{a}_{m,p} T_{m,p,t} + \sum_{p}\sum_{m}\sum_{d} \bar{a}_{p,h,s} \bar{a}_{m,p} \bar{a}_{d,m} T_{d,m,t} \dots$$

$$T_{h,t}^{down} = (I - \bar{A})\text{^}(-1)\, B^{down}\, e^{down\prime}$$

$$\text{where} \quad e^{down} = ones_{1xC} \quad \text{and} \quad B^{down} = \bar{X} \circ T$$

Given the use of the international input-output tables and their cumulative sums along the value chain, the natural scaling of the upstream and downstream tariffs is as a share of output, which results in smaller magnitudes than nominal tariff rates.

Domestic Protection: Captures the domestic protection of a given country-sector from international competition**.** Changes therein affect the domestic demand. To make it clear that domestic protection uses trade weights only within a given sector, sub-indexes *c* and *i* are used for the home country and industry and *s* for the source country.

$$T_{c,i,t}^{dp} = \sum_{s} \bar{\omega}_{c,i,s}^{M} T_{c,i,s,t}$$

$$\text{where} \quad \bar{\omega}_{c,i,s}^{M} = \frac{1}{T} \sum\nolimits_{t} \frac{M_{c,i,s,t}}{\sum_{j \neq c} M_{c,i,j,t}}$$

The tariff data is taken from the "World Integrated Trade Solution Platform" at the HS6 product level. For many countries, missing data points are prevalent at this detailed level of aggregation. To assure that changes in the aggregate tariff measures are not driven by composition, missing observations are linearly interpolated at the HS6 product level. The level is kept constant when the missing observations are either at the beginning or the end of the sample. The aggregation from the product- to the sector level uses trade-weights over the first three available years (generally 1995-97).

Diversion: The average tariff imposed by partner countries on all other suppliers except the country-sector in question. The subscripts c and i refer to the home country and industry, p to the partner country and s the other source countries for exports in the same industry. The weights are respectively the import share of the partner country from all other countries (excluding home; the second summation) and the export of home to all other partners (the first summation).

$$T_{c,i,t}{}^{div} = \sum_{p \neq c} \overline{\omega}^{X}_{c,i,p} \sum_{s \neq c} \overline{\omega}^{M}_{p,i,s} \, T_{p,i,s,t}$$

$$\text{where} \quad \overline{\omega}^{X}_{c,i,p} = \frac{1}{T} \textstyle\sum_t \frac{X_{c,i,p,t}}{\sum_{j \neq c} X_{c,i,j,t}} \quad ; \quad \overline{\omega}^{M}_{p,i,s} = \frac{1}{T} \textstyle\sum_t \frac{M_{p,i,s,t}}{\sum_{j \neq c,s} M_{p,i,j,t}}$$

C. Regression Model

The above tariff measures are the key explanatory variable in the regression model:

$$\ln\left(y_{c,i,t}\right) = \alpha + \beta_1 L.T^{up}_{c,i,t} + \beta_2 L.T^{down}_{c,i,t} + \beta_3 L.T^{dp}_{c,i,t} + \beta_1 L.T^{div}_{c,i,t} + \gamma_{c,t} + \delta_{c,i} + \varepsilon\_(c,i,t)$$

The dependent variable y represents a set of economic outcome variables (real value added, employment, labor productivity and total factor productivity)[15], and is regressed on the lags of the various tariff measures and country-time and country-industry fixed effects. Country-industry fixed effects absorb structural and time-invariant aspects of the given industry, while country-time fixed effects absorb time-varying macro-economic determinants, including the country's business cycle and the exchange rate. These fixed effects allow a more precise identification of the coefficients, however they make it impossible to determine aggregate and general equilibrium effects of tariffs (including effects on the exchange rate).

[15] The sectoral outcome variables are taken from EU KLEMS and World KLEMS (Jäger 2018, Jorgenson 2017).

D. Results

The Table shows the results for a one percentage-point change in the respective tariff measures.

Table 7. Tariff Effects on Economic Variables

	(1)	(2)	(3)	(4)
	VA	**Empl.**	**L-Prod.**	**TFP**
L.T_upstream	-19.41***	-8.49**	-6.53*	-11.52**
	(6.81)	(4.25)	(3.85)	(4.70)
L.T_downstream	-14.47**	-1.33	-12.61***	-13.19**
	(6.03)	(4.26)	(4.67)	(6.39)
L.T_D_protect	0.02	-1.87**	0.92	0.37
	(0.65)	(0.88)	(0.89)	(0.38)
L.T_diversion	5.14*	6.02**	1.29	-2.70
	(2.79)	(2.58)	(2.10)	(4.19)
Cou-Year FE	Yes	Yes	Yes	Yes
Cou-Ind FE	Yes	Yes	Yes	Yes
N	6774	6097	6144	4112
R-sq	0.733	0.993	0.734	0.693

Note: VA = real value added; Empl. = number of employees; L-Prod. = labor productivity and TFP = total factor productivity. Dependent variables are expressed in natural logarithm. Errors are clustered at the country-sector level. SE in parentheses; * $p<0.10$** $p<0.05$ *** $p<0.01$

However, using different weighting schemes (by input use vs. trade shares) results in different magnitudes for the different tariff measures , which make the regressors hard to compare[16]. Therefore, to appropriately compare the effect of changes of the different tariffs, the table below looks at the impact of a one standard deviation change in each regressor.

Table 8. Tariff Effects on Different Real Variables; normalized with C-Y and Ind-FE

	(1)	(2)	(3)	(4)
	VA	**Empl.**	**L-Prod.**	**TFP**
L.T_upstream	-16.18***	-7.09**	-5.45*	-9.60**
	(5.68)	(3.54)	(3.21)	(3.91)
L.T_downstream	-11.93**	-1.09	-10.40***	-10.87**
	(4.97)	(3.51)	(3.85)	(5.27)
L.T_D_protect	0.10	-10.90**	5.42	2.17
	(3.80)	(5.17)	(5.20)	(2.25)
L.T_diversion	10.98*	12.79**	2.75	-5.76
	(5.96)	(5.51)	(4.48)	(8.94)
Cou-Year FE	Yes	Yes	Yes	Yes
Cou-Ind FE	Yes	Yes	Yes	Yes
N	6774	6097	6144	4112
R-sq	0.733	0.993	0.734	0.693

Note: VA = real value added; Empl. = number of employees; L-Prod. = labor productivity and TFP = total factor productivity. Tariffs are normalized by the standard deviation of the VA-sample. Dependent variables are expressed in natural logarithm. Errors are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Both tables show significant negative coefficients for the upstream and downstream tariffs, but—with the exception of the effect on employment—often insignificant coefficients for domestic protection. The effect of the diversion tariff is positive and statistically significant for value added and employment, but insignificant for labor productivity and TFP.

The next table tests the robustness of the results relative to lag length. In the baseline regression, tariffs enter with a lag. This largely follows the literature and is an attempt to partly reduce the issue of reversed causality. However, lacking exogenous instruments, the risk of endogeneity cannot be fully rejected. Assuming that the risk of endogeneity declines with time, the Table reports the sensitivity of the value-added coefficients to entering the tariffs with a lag

[16] Upstream and downstream tariffs are constructed using input weights as a share of output, which do not add up to 1. By consequence, they tend to be smaller in size than the other two tariff measures, making a one-unit change a proportionally more important shock.

greater than 1. It shows that the coefficients generally decline and the estimation gets less precise—both are a natural consequence of increasing the time span between cause and effect. The results however remain qualitatively unchanged and generally statistically significant.

Table 9. Robustness to Lag-order; Effect on VA

	(1)	(2)	(3)
	L1	**L2**	**L3**
T_upstream	-19.41***	-18.53***	-17.18***
	(6.81)	(6.62)	(6.18)
T_D_protect	0.02	-0.02	-0.00
	(0.65)	(0.64)	(0.58)
T_downstream	-14.47**	-12.75**	-11.43**
	(6.03)	(5.64)	(5.25)
T_diversion	5.14*	4.37	3.73
	(2.79)	(2.68)	(2.54)
Cou-Year FE	Yes	Yes	Yes
Cou-Ind FE	Yes	Yes	Yes
N	6774	6361	5948
R-sq	0.733	0.719	0.709

Note: Effect of Tariffs on value added depending on whether tariffs are lagged by one (L1), two (L2) or three (L3) years. Errors are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

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