A Simple Method to Estimate the Effects of Non-discriminatory Trade Policy within Structural Gravity Models*

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Abstract

We propose a simple method to obtain estimates of the effects of non-discriminatory trade policy within the structural gravity model. An important byproduct of our procedures is that they can be used to obtain estimates of the trade elasticity of substitution, which has established itself as the single most important parameter in the international trade literature. We illustrate our approach by using panel manufacturing trade and production data for the period 1996-2012.

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1 Introduction and Motivation

Many researchers attempt to estimate the trade effects of unilateral or non-discriminatory trade policy on bilateral trade flows. Examples are classic trade policy measures like most favored nation (MFN) tariffs or non-tariff barriers like trade facilitation measures.

Within the structural gravity model, using data on international trade only, the effects of these policies cannot be identified as they are perfectly collinear with the importer and exporter fixed effects which have to be included to control for the multilateral resistance terms, as pointed out by e.g. Head and Mayer (2014).

We demonstrate that estimates of non-discriminatory trade policy can be obtained in a structural gravity model when data on domestic trade are available.

Specifically, our paper makes three contributions: 1.) a methodological one by presenting a simple method to obtain estimates of the trade effects of unilateral or non-discriminatory trade policies, 2.) it contributes to the literature on the trade effects of MFN tariffs, and 3.) it contributes to the vast literature which tries to uncover trade elasticities. Whereas bilateral measures of effectively applied tariffs have previously been used to identify the trade elasticity in structural gravity frameworks, MFN tariffs have not been used to date as the literature so far has focussed on estimating gravity models using *inter*national trade data only and, as noted above, the effects of MFN tariffs were absorbed by the importer or importer-time fixed effects in structural gravity models.[1]

In order to achieve these goals we propose a simple adjustment to the empirical gravity model, which is perfectly consistent with the structural gravity theory. Specifically, in addition to using international trade flows data to estimate gravity, we also use intra-national trade data. This enables us to identify estimates of any non-discriminatory trade policy, even in the presence of exporter-time and importer-time fixed effects as suggested by theory. Our identification strategy relies on the fact that while trade policy is non-discriminatory, it

[1] Anderson and van Wincoop (2003) use data on internal trade in their analysis of the border effect between the United States and Canada; however, they do not use tariff data to estimate the trade elasticity of tariffs.

only applies to international trade, not to domestic trade. Estimates of the trade elasticity of substitution are recovered directly from the estimates of the coefficient on MFN tariffs, which are also the predominant form of non-discriminatory trade policy for which data is available over a longer period of time and for a wide range of countries.

2 Theoretical Foundation

As pointed out by Head and Mayer (2014), a large class of trade models imply the following structural gravity equation for bilateral trade flows X_{ij} from country i to j:

$$X_{ij} = \frac{Y_i}{\Omega_i}\frac{E_j}{P_j}\mathcal{T}_{ij}, \tag{1}$$

where $\mathcal{T}_{ij}$ is a function of bilateral trade costs between i and j, inclduing both tariffs and non-tariff trade costs. Its functional form depends on the specific trade model chosen by the researcher. Structural gravity models impose the condition that the value of production in country i equals its total sales to all countries, including domestic sales, $Y_i = \sum_j X_{ij}$, and expenditure in country j equals the sum over all imports, $E_j = \sum_i X_{ij}$. Ω_i and P_j are outward and inward multilateral resistance terms which are defined by the following system of equations

$$\Omega_i = \sum_m \Phi_m^{-1}\mathcal{T}_{im}E_m, \quad P_j = \sum_m \Omega_m^{-1}\mathcal{T}_{mj}Y_m. \tag{2}$$

The same equations apply at the aggregate and sector level when according measures of sectoral production and expenditure are used.

What remains is the specific form of $\mathcal{T}_{ij}$. In general, $\mathcal{T}_{ij}$ can be decomposed into two parts:

$$\mathcal{T}_{ij} = \tau_{ij}^{\epsilon_1} T_{ij}^{\epsilon_2}, \tag{3}$$

where τ_{ij} is a direct demand shifter like MFN tariffs. Note that we define τ_{ij} to be 1 + the MFN tariff rate. ϵ_1 is a direct measure of the demand elasticity of exports with respect to price. In the Anderson and van Wincoop (2003) structural gravity framework, it is equal to $-\sigma$, the elasticity of substitution between varieties from different countries. T_{ij} is a measure of non-tariff barriers. Many researchers specify non-tariff barriers as a function of, inter alia, bilateral (log) distance between countries, whether countries share a common border, language, colonial history or trade agreement membership. In general, they specify $T_{ij} = \prod_f t_{ij,f}^{\delta_f}$, where $t_{ij,f}$ are the individual measures of non-tariff barriers as mentioned above and δ_f is the corresponding tariff equivalent trade cost elasticity of barrier f. Again, in the Anderson and van Wincoop (2003) framework, ϵ_2 equals $(1-\sigma)$. The different elasticities between tariffs and non-tariff barriers stem from the fact that tariffs are paid by the consumer and hence are applied to the price of goods including trade costs, whereas non-tariff trade costs are borne by the producer.[2] As is well known by now (see e.g. Arkolakis, Costinot, and Rodríguez-Clare, 2012 and Head and Mayer, 2014), using a Eaton and Kortum (2002) framework replaces $(1-\sigma)$ by $-\theta$, a parameter which measures the variability of productivity across countries. For expositional convenience, we will stick to the Anderson and van Wincoop (2003) framework from now on, while it is understood that our method to estimate the elasticity of substitution between varieties can also be interpreted as a method to estimate the technology parameter θ.

[2] Obviously, the actual incidence of trade costs and tariffs is a different matter, see Anderson and Yotov (2010).

3 Empirical Analysis

To demonstrate our method we obtain estimates of the effects of MFN tariffs within the structural gravity model from Section 2. MFN tariffs fit our purpose perfectly because: (i) MFN tariffs fit the definition of a non-discriminatory trade policy; (ii) MFN tariffs are the prevailing form of trade protection due to WTO rules; (iii) MFN tariffs are a direct price shifter, which implies that we can recover an estimate of the trade elasticity of substitution from the estimate on MFN tariffs within the structural gravity model.

3.1 Econometric Specification

We can rewrite Equation (1) to receive the following estimable equation:

$$X_{ijt} = \exp(\beta_1 RTA_{ijt} + \sigma \ln \tau_{jt}^{MFN} + \eta_{it} + \mu_{jt} + \xi_{ij} + \varepsilon_{ijt}), \tag{4}$$

where τ_{jt}^{MFN} is one plus the MFN tariff rate country j levies for all exports which enter the country and which do not apply for a lower tariff using rules of origins for a specific bilateral or regional trade agreement, if applicable. We also added a time subscript t as we use panel data to be able to control for directed country pair fixed effects ξ_{ij}. These control for standard gravity variables like bilateral distance, common language, etc. Note that $\beta_1 = \delta_1(1-\sigma)$. The important difference to standard gravity estimations is that our data set includes internal trade data X_{iit} as well.[3] Also note that the MFN tariff only applies to international trade flows, hence $\tau_{jt}^{MFN} = 1$ for all internal trade flow observations. The importer and exporter fixed effects η_{jt} and μ_{jt} control for all trade cost variables which are importer and exporter specific as well as for the time-varying multilateral resistance terms, see Anderson and van Wincoop (2003).

Here, it is instructive to stress our key identification strategy again: if we were to estimate

[3] Internal trade data are also used by Yotov (2012) and Bergstrand, Larch, and Yotov (2015) to solve the globalization and distance puzzle. However, they do not analyze non-discriminatory trade policies.

Equation (4) on a data set with only international trade data, $\ln \tau_{jt}^{MFN}$ would be perfectly collinear with the importer fixed effect μ_{jt}, as the MFN tariff is the same for all countries exporting to country j in the data set.[4] Including domestic trade flows, however, breaks this collinearity as $\ln \tau_{jt}^{MFN} = 0$ if $i = j$, but $\ln \tau_{jt}^{MFN} \neq 0$ if $i \neq j$.

We estimate Equation (4) separately for each 2-digit industry, hence we allow the tariff equivalents of the different regressors as well as the elasticity of substitution to vary across industries.

As is well known, trade flows exhibit a large degree of heteroscedasticity. In this case, estimating a log-linearized version of (4) leads to inconsistent parameter estimates due to Jensen's inequality, see Santos Silva and Tenreyro (2006). We therefore follow Santos Silva's and Tenreyro's suggestion and estimate our model by using a Pseudo Maximum Likelihood Estimator (PPML). For comparison reasons, we also present the OLS results, though.

Obviously, trade policies like the level of tariffs or whether two countries sign a regional trade agreement are not randomly assigned across countries, see e.g. the arguments in Trefler (1993) and Magee (2003). For example, countries which are closer have a significantly higher probability of signing an RTA, see e.g. Baier and Bergstrand (2004) and Egger, Larch, Staub, and Winkelmann (2011). Therefore, both the RTA regressor as well as our measure for the non-discriminatory trade policy, τ_{it}^{MFN}, are potentially endogenous. Matching techniques to correct for the selection bias are hampered by violations of the stable unit treatment value assumption (SUTVA) as trade policy has by definition general equilibrium and third country effects via its impact on trade creation and diversion (see e.g. Viner, 1950). Instrumental variables which fulfill the necessary exclusion restriction are hard to come by at the country or industry level. We therefore follow Baier and Bergstrand (2007) and include (directed)

[4] MFN tariffs only apply to WTO member states. However, many countries apply their MFN tariff also to non-WTO members. In our data set, we apply the MFN tariff to all countries to ensure that it really is non-discriminatory across countries. As of July 2015, the following countries are not members of the WTO: Afghanistan, Algeria, Andorra, Azerbaijan, Bahamas, Belarus, Bhutan, Bosnia and Herzegovina, Comoros, Equatorial Guinea, Eritrea, Ethiopia, Holy See, Iran, Iraq, Kazakhstan, Kiribati, Lebanese Republic, Liberia, Libya, Marshall Islands, Micronesia, Monaco, Nauru, North Korea, Palau, Palestine, San Marino, Sao Tomé and Principe, Serbia, Somalia, South Sudan, Sudan, Syria and Uzbekistan.

country-pair effects to control for the endogeneity of trade policy.

3.2 Data

To calculate domestic trade flows at the industry level, we need data on production. We use the INDSTAT2 Industrial Statistics Database at the 2-digit level of the International Standard Industrial Classification of All Economic Activities (ISIC) Revision 3. It contains production data for 23 industries of the manufacturing sector and is provided by UNIDO.[5] We construct domestic trade flows as domestic production value minus total exports for every industry.[6]

We use the according trade data from UNCOMTRADE which we access via the World Integrated Trade Solution (WITS) website which provides UNCOMTRADE data in the ISIC nomenclature. WITS also provides MFN tariff rates.[7]

Our measure of regional trade agreements comes from Mario Larch's RTA Database.[8]

For our cross-sectional regressions, we cannot control for bilateral fixed effects. Instead, we use a set of standard gravity control variables provided by CEPII.[9]

In creating our data set, we keep every country pair observation which we observe at least twice such that the bilateral fixed effects do not perfectly predict bilateral trade flows by construction.

After merging our data sets, we end up with data for 106 importing and 133 exporting countries for the years from 1996 to 2012. Note that the data set is not balanced as MFN tariffs are not available for every year. Following the recommendation by Cheng and Wall

[5] It can be accessed via `http://www.unido.org/en/resources/statistics/statistical-databases.html`.

[6] Several countries report only combined data on production values for several industries for some years. For example, Albania only reports the combined output for ISIC industries 15 (food and beverages) and 16 (tobacco products) in 1986. In these cases, we impute production values by calculating the world output share for the pertaining industries and apportion the total production value accordingly. We do this for every year in the data set to allow for a structural change of these value weights over time due to technological progress.

[7] It can be accessed via `http://wits.worldbank.org/default.aspx`.

[8] It can be accessed via `http://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html`.

[9] See Mayer and Zignago (2011) for a detailed description of the data.

(2005) we only use every third year starting in 1999 to 2011 for our estimations instead of the full panel.

3.3 Estimation Results and Analysis

A first set of estimation results are reported in Table 1.[10] These estimates are obtained with panel PPML, 4-year intervals, a set of standard gravity variables, and the full sets of importer-time and exporter-time fixed effects. The estimates on the standard gravity covariates are in accordance with our prior expectations. More important, all estimates on MFN tariffs are negative and most of them are statistically significant. Some of the estimates are a bit large, but we should be able to address this in the sensitivity experiments. One such experiment is when we use pair fixed effects. Estimation results are reported in Table 2. Six of the tariff estimates are negative. Five of them are statistically significant. The negative and significant estimates seem more reasonable in terms of magnitude. One estimate is positive and (marginally) statistically significant.

4 Conclusion

The trade creation effects of unilateral or non-discriminatory trade policies are of primordial relevance for both academics as well as policy makers. Using domestic trade data, we propose a simple method to identify the trade effects of such policies in structural gravity models. Our method can be applied to any policy which applies equally to all importing or exporting countries. We illustrate our approach by evaluating the trade effects of most favored nation (MFN) tariffs on bilateral trade using a panel of trade and production data (ISIC, Revision 3 at the 2-digit level). In principle, our approach can also be used to separately identify export supply from demand elasticities of bilateral trade flows using data on (implicit) export subsidies.

[10] Please note that Tables 1 and 2 do not use the final data set but a preliminary version of the data subject to change.

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Tables

Table 1: Sectoral Gravity Estimates, Panel PPML with Gravity Variables

	(1) Food	(2) Textile	(3) Wood	(4) Paper	(5) Chemicals	(6) Minerals	(7) Metals	(8) Machinery
LN_DIST	-1.099	-1.263	-1.239	-1.266	-1.011	-1.188	-0.994	-0.854
	(0.096)**	(0.101)**	(0.099)**	(0.082)**	(0.058)**	(0.097)**	(0.089)**	(0.058)**
CONTIG	0.518	0.083	0.678	0.451	0.162	0.646	0.794	0.376
	(0.187)**	(0.168)	(0.182)**	(0.160)**	(0.119)	(0.194)**	(0.165)**	(0.120)**
LANG	0.211	0.175	0.098	0.631	0.266	-0.071	0.179	0.224
	(0.197)	(0.239)	(0.218)	(0.169)**	(0.132)*	(0.160)	(0.155)	(0.117)+
CLNY	0.157	0.093	0.199	-0.120	-0.053	0.186	-0.035	-0.247
	(0.219)	(0.232)	(0.205)	(0.208)	(0.132)	(0.179)	(0.158)	(0.162)
SMCTRY	2.397	1.134	2.629	2.404	1.107	2.221	1.151	0.578
	(0.273)**	(0.438)**	(0.205)**	(0.187)**	(0.145)**	(0.267)**	(0.260)**	(0.173)**
ln(1+MFNTAR)	-6.389	-0.613	-3.695	-8.377	-18.557	-11.628	-22.322	-14.736
	(0.735)**	(3.920)	(2.474)	(1.283)**	(2.070)**	(1.889)**	(2.030)**	(1.743)**
N	4963	4898	4929	4956	4940	4964	4902	4899

Notes: This table reports sectoral estimates with manufacturing data. All estimates are obtained with exporter-time and importer-time fixed effects. Robust standard errors (clustered by country pair) are reported in parentheses. + $p < 0.10$, * $p < .05$, ** $p < .01$.

Table 2: Sectoral Gravity Estimates, Panel PPML with Pair Fixed Effects

	(1) Food	(2) Textile	(3) Wood	(4) Paper	(5) Chemicals	(6) Minerals	(7) Metals	(8) Machinery
ln(1+MFNTAR)	0.633	-18.997	0.241	-1.401	-7.994	-6.783	-8.166	-11.211
	(0.336)+	(5.031)**	(1.517)	(1.439)	(1.018)**	(1.420)**	(2.113)**	(0.925)**
N	4963	4898	4929	4956	4940	4964	4902	4899

Notes: This table reports sectoral estimates with manufacturing data. All estimates are obtained with pair fixed effects, exporter-time fixed effects, and importer-time fixed effects. Robust standard errors (clustered by country pair) are reported in parentheses. + $p < 0.10$, * $p < .05$, ** $p < .01$.

Table 3: Description of ISIC Revision 3 2-digit Industries

ISIC3	industry name
15	food products and beverages
16	tobacco products
17	textiles
18	wearing apparel; dressing and dyeing of fur
19	tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear
20	wood and of products of wood and cork, except furniture; articles of straw and plaiting materials
21	paper and paper products
22	publishing, printing and reproduction of recorded media
23	coke, refined petroleum products and nuclear fuel
24	chemicals and chemical products
25	rubber and plastics products
26	other non-metallic mineral products
27	basic metals
28	fabricated metal products, except machinery and equipment
29	machinery and equipment n.e.c.
30	office, accounting and computing machinery
31	electrical machinery and apparatus n.e.c.
32	radio, television and communication equipment and apparatus
33	medical, precision and optical instruments, watches and clocks
34	motor vehicles, trailers and semi-trailers
35	other transport equipment
36	furniture; manufacturing n.e.c.