The Gravity Model of Trade

Often referred as the “workhorse” of international trade, the gravity model is prominent in the empirical literature of applied international trade analysis. Among the arguments that could support the use of the gravity model, there are four that are particularly relevant for our purposes. First, the gravity model of trade is intuitive to understand. Following the metaphor of Newton’s Law of Universal Gravitation, it predicts that international trade between two countries is directly proportional to the product of their economic size, and inversely proportional to trade frictions between them. In simpler words, the bigger (smaller) the economies of two countries, and the easier (harder) it is for them to trade with each other, the more (less) we expect them to trade. Second, it is referred to as a structural model with solid theoretical foundations, which makes it appropriate for counterfactual analysis, such as measuring the effects of trade policies as we aim to do with the effects of North-South versus South-South agreements. Third, model has a flexible structure, which will allow us to construct a specification tailored to our research. Finally, fourth, it holds consistent and remarkable predictive power, both with aggregate and sectoral data (Yotov et al. 2016).

Through the decades, the gravity equation has been regularly upgraded in the theoretical and empirical literature. Of relevance, the simple intuition of the gravity model was theoretically extended by Anderson to note that, after controlling for size, the increase or decrease is *relative* to the average barriers of the two countries with all their partners, which are referred as “multilateral resistance” (Anderson 1979). The more trade barriers or resistance to trade exists with other countries relative to a given partner, the more a country is pushed to trade with said partner. Anderson also introduced the assumptions of product differentiation by place of origin, and Constant Elasticity of Substitution (CES) expenditures, or the Armington-CES assumption (Yotov et al. 2016; Chatzilazarou and Dadakas 2023), which led us to today’s generalized form of the gravity equation, as developed and popularised by Anderson and van Wincoop (Anderson and van Wincoop 2003).

Equally important, several empirical developments have strengthened the gravity model and inform our choice of methodology: Exporter-time and importer-time fixed effects are used to account for the multilateral resistance terms in a gravity estimation with panel data (Olivero and Yotov 2012); As the gravity model is often estimated with an OSL estimator, zero-trade flows were dropped from the sample when trade was transformed into a logarithmic form. Also, trade data is recognized to suffer from heteroscedasticity (Yotov et al. 2016). To solve for zero-trade flows and heteroscedasticity, the Poisson Pseudo Maximum Likelihood (PPML) estimator has been proposed to estimate the gravity model, avoiding potential biases (Silva and Tenreyro 2006; Santos Silva and Tenreyro 2011); Country-pair fixed effects has been proposed to account for the unobserved endogeneity of trade policy (Baier and Bergstrand 2007). It is worth nothing that the inclusion of exporter-time and importer-time fixed effects will absorb all observable and unobservable time-varying country-specific characteristics that could affect the dependent variable, while the country-pair fixed effects will absorb observable and unobservable bilateral time-invariant characteristics that could affect trade costs; The inclusion of intra-trade flows as well as international trade flows is proposed to correctly estimate the effects of non-discriminatory trade policy, allowing for consumers to choose products from both international and domestic sources (Dai, Yotov, and Zylkin 2014; Heid, Larch, and Yotov 2017); Year-intervals instead of data pooled over consecutive years should be used to allow for adjustment of trade flows to policies that might not have immediate effects (Baier and Bergstrand 2007; Anderson and Yotov 2016); And finally, to account for the effects of globalization forces that may biased the estimates of trade policies, a set of globalization dummies are recommended to control for the effects of globalization in the gravity model (Yotov 2012; Bergstrand, Larch, and Yotov 2015).

Benchmark Model

Based on the theoretical and empirical best-practices found in the relevant literature, we employ the following gravity equation using a PPML estimator and a balanced panel data approach with multiple exporters, multiple importers and time as our benchmark model:

Where denotes the value of exports from an origin country to a destination country ; and are, respectively, exporter-time and importer-time fixed-effects; is a country-pair fixed-effect; and are our main variables of interest, which, respectively indicate if and are members of a PTA at time and, to account for potential “phase-in” effects over time of the PTA, at time ; is a set of dummies that equal 1 for international trade and 0 for domestic trade observations at each time ; and is an error term.

PTA Heterogeneity Model

In contrast with our main interest of research, which are the potential heterogenous effects of PTAs on different members for different types of agreements, this benchmark model, specifically , would provide the average “total” partial effect of PTAs on trade after accounting for lagged effects, but it cannot provide the effects for a given agreement. As such, an expansion can be implemented to capture heterogeneity in PTA effects as proposed by Baier *et al*. (Baier, Yotov, and Zylkin 2019):

Equation (2) can be implemented to account for heterogeneous effects of PTAs at the level of the specific agreement, by allowing for distinct average partial effects for each individual agreement, using superscript to index by agreement and also allowing for agreement-specific lags: .

North-North, North-South and South-South PTAs

In order to analyse the differentiated effects of North-North, North-South and South-South PTAs, we extend both models to get estimates for each type of PTA. Our benchmark model is extended as follows:

Where ​ denotes the value of exports from country to country at time ; and are exporter-time and importer-time fixed effects, respectively; is a country-pair fixed effect; ​ and are the coefficients for the immediate and lagged effects of a North-North PTA (); ​​ and are the coefficients for the immediate and lagged effects of a North-South PTA (); ​​ and are the coefficients for the immediate and lagged effects of a South-South PTA (); is a set of time dummies accounting for international trade-specific effects at each time ; and is the error term.

Equation (2) also gets extended to capture the heterogeneous effects of the different types of PTAs as follows:

Where ​ denotes the value of exports from country to country at time ; and are exporter-time and importer-time fixed effects, respectively; is a country-pair fixed effect; The summations ​ denote the sum over different agreements for: and : Coefficients for the immediate and lagged effects of North-North PTAs ​(); and : Coefficients for the immediate and lagged effects of North-South PTAs (); and : Coefficients for the immediate and lagged effects of South-South PTAs (); is a set of time dummies accounting for trade-specific effects at each time ; and is the error term.

For both extended models we use the following variables: is a dummy variable that takes the value of 1 if the trade pair is North-North and part of a PTA at time , and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is North-North and was part of a PTA at time *-5*, and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is North-South and part of a PTA at time , and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is North-South and was part of a PTA at time *-5*, and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is South-South and part of a PTA at time , and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is South-South and was part of a PTA at time *-5*, and 0 otherwise;

The extended models allow us to capture the differentiated effects of PTAs on bilateral exports depending on whether the pair country are two “North” countries (NN), a “North” and a “South” country (NS), or two “South” countries (SS).

Export Product Unit Value

Inspired by other strands of the international trade literature, we also test our models using “Unit Values” of the products exported, by dividing the total value exported by the total weight exported in kilograms (Latzer and Mayneris 2021; Manova and Zhang 2012; Bastos and Silva 2010). Using the unit value as the dependent variable in our estimations allow us to analyse if the value per unit exported is affected by PTAs. To be consistent in our effort to understand the potentially heterogenous effects of PTAs according to the different category of the members in trade volume, but also in quality upgrading and industrialization development of countries, we focus on manufacturing products (Chatzilazarou and Dadakas 2023) with HS 2-digit codes 84 (Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof ) and 85 (Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles) which are part of the “Machinery and mechanical appliances; electrical equipment; parts thereof; sound recorders and reproducers, television image and sour sound recorders and reproducers, and parts and accessories of such articles” category from the World Customs Organization. Our aim is to compare the effects of PTAs on trade volumes against the effects on the unit value of manufacturing products exported.

Defining North and South

Defining which countries belong to the “North” and “South” categories is a key step in order to properly analyse the impact of PTAs on different bilateral export relationships. However, it is important to consider that any way in which we categorize countries can be criticised for not taking into consideration the diverse and heterogenous characteristics of individual countries within each group. Furthermore, especially since our focus is to analyse South-South relationships, it is possible to further disaggregate from the “South” group the emerging economies which are becoming more relevant at the political and economic world stage and are challenging the hegemony of traditional developed economies. The level of disaggregation, as well as the level of attention to heterogenous characteristics among and within groups, depends on the research question at hand. For the purposes of this paper, we will not consider such heterogeneity within groups, and just focus on categorising countries as “North” and “South”, but by no means does this assumes that countries are homogenous within groups. This is just a useful distinction to study heterogeneity across PTA effects.

One intuitive approach could be to categorize countries based on their income level, but this approach would need to deal with a dynamic list of groups, as countries change their category through time. Also, high-income countries include non-industrialized small-nations which we do not expect to generate significant effects on the industrial development as well as technology- and skills-upgrading of trade-partner countries. For such reasons, we have decided to use the same categorization of countries as Dahi & Demir (Dahi and Demir 2017) which takes into consideration characteristics such as incomes, production and trade structures, factor endowments, and human and institutional development to construct a list of “North” and “South” countries, and also keeps the groups consistent over time. This results in 23 countries categorized as “North”, and the rest as “South”. A detailed list of the countries and their categories can be found in the Appendix.

Data

To construct our dataset we have combined PTA data from the “Design of International Trade Agreements” (DESTA) (Dür, Andreas, Leonardo Baccini and Manfred Elsig 2014) and from the CEPII “Trade and Production Database” (TradeProd) (Thierry Mayer, Gianluca Santoni, Vincent Vicard 2023). The DESTA database aims to aggregate all agreements that have the potential to liberalise trade, including all agreements notified to the World Trade Organisation (WTO) and other agreements from a wide range of sources, covering 880 agreements for 204 countries since 1948 to 2023 in the last updated version.

Our sample consists of PTAs signed between the years 2000 to 2010 and the country members to these PTAs, totalling 154 agreements and 143 member countries. For ease of estimation, and to get a sense of geographical differences, we estimate our models by PTA region for five main regions: Africa, Americas, Asia, Europe and Intercontinental (We exclude Oceania [11 countries and 1 agreement] for lack of sufficient trade data for our estimations). Each region has the following samples of agreements and countries: Intercontinental (114 countries and 64 agreements), Europe (42 countries and 41 agreements), Asia (35 countries and 33 agreements), Americas (15 countries and 13 agreements) and Africa (10 countries and 2 agreements).

For all countries in our sample, we get international trade and domestic trade flows from the TradeProd database, which has been created specifically for estimating gravity models and combines trade data from the UN Commodity Trade Statistics Database (COMTRADE) and production data from UNIDO Industrial Statistics database (INDSTAT). We also download export data directly from COMTRADE for all countries in our sample to construct our export product unit value measurements. For estimations on trade flows, we use international trade flow data as reported by importer. In order to measure the appropriate lags for the effects of each agreement, our period of interest for international flow data is between 1995 to 2015, and since we are estimating in 5-year intervals, we get trade flow data for the years 1995, 2000, 2005, 2010 and 2015. Finally, as mentioned before, export product unit values are constructed using the total value exported per product per year divided by the net weight exported of said product for said year at the HS 2-digit code level for the 84 and 85 codes for manufacturing products. As it is not possible to get data for product unit values for domestic trade, the estimations using this measure as the dependent variable will suffer from bias as the estimation does not include intra-trade effects. However, the direction of bias is important as not including intra-trade measures is expected to bias the effects of PTAs downwards (Yotov et al. 2016), so we use this estimates as illustrative conservative measurements of the effects of PTAs on the unit value of exported products.

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