**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 explain/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 South-North 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). 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.

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, country-pairs o specific country members to a specific agreement. As such, three successive expansions 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: .

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 part of a North-North PTA at time , and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair was part of a North-North PTA at time *-5*, and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is part of a North-South PTA at time , and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair was part of a North-South PTA at time *-5*, and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair is part of a South-South PTA at time , and 0 otherwise; is a dummy variable that takes the value of 1 if the trade pair was part of a South-South 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 they are between two “North” countries (NN), between a “North” and a “South” country (NS), or between two “South” countries (SS).

**Defining South and North**

**Data**

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