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Does Aid Cause Trade? Evidence from an Asymmetric Gravity Model

by

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Abstract

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JEL classification: F10

Keywords: Foreign aid, trade, gravity

Outline

Non-Technical Summary

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1) Introduction

The gravity model has become a major tool in empirical international economics. Part of the reason for this is the model's success in accounting for trade patterns, but the boom in new use of gravity modeling came with the development of solid theoretical foundations.[1] A major advance in the development of these theoretical foundations came with the fundamental paper by Anderson and van Wincoop (AvW, 2003), who clarify the appropriate way to incorporate barriers to trade, broadly speaking, in the gravity framework. Before this seminal contribution, the traditional gravity equation specification ignored that the volume of trade between two countries is not only influenced by their bilateral trade costs but also by trade costs between these two countries *relative* to the total volume of trade among all countries. Alternatively, as nicely argued by Baer and Bergstrand (2007, page 5):

> "In reality, the trade flow from i to j is surely influenced by the prices of products in the other N–2 regions in the world, which themselves are influenced by the bilateral distances (and EIAs, etc.) of each of i and j with the other N–2 regions."[2]

On the other hand, as is well known, AvW relied on strong symmetry assumptions in deriving their framework. In many applications (e.g. border effects between countries at a similar level of economic development) these assumptions seem quite plausible. However, in applications with an explicit North-South component, symmetry seems problematic.

One such application is the study of the link between trade and aid. The goal of this paper is to develop an asymmetric version of the AvW model appropriate to applications explicitly involving developed and less developed countries. Since aid is usually a transfer from developed to less developed countries, the AvW approach to the gravity equation, as proposed by AvW (2003) needs to be re-derived in the presence of such

[1] Fundamental papers here include: Anderson (1979), Bergstrand (1985, 1989), and Helpman (1987). Deardorff (1998) provides a useful discussion of the wealth of theoretical foundations available, while Feenstra, Markusen and Rose (1999), Evenett and Keller (2002), and Haveman and Hummels (2004), among others, seek to evaluate these various foundations empirically.
[2] By EIAs the authors mean economic integration agreements.

transfers and where the North produces differentiated goods and the South homogenous ones. It is argued here that these different structures better characterize developed and less developed countries (see also Helpman, 1999).

The next section seeks to situate the research reported here relative to the existing literature on the trade-aid link and some of the related work on the gravity model; then we present our extension of AvW to the asymmetric North-South case; this is followed by a discussion of the econometric method [an application of Baier and Bergstrand's (B&B, 2007) OLS-based implementation of the AvW model]; this is followed by a presentation of results; and the paper concludes. By building on the work of AvW and B&B, the extension developed here increases the efficiency of estimation and allows us to better interpret the results. We believe that this provides an empirical model that is better suited to the analysis of North-South trade issues like the link between trade and aid.

2) Trade, Aid, and the Gravity Model

The literature on foreign aid and how it is related to trade is vast. In particular, the issue of causality between these two variables has received a lot of attention.[3] Probably the most widely held view is that aid causes trade, and the most direct channel for this effect is that aid is often tied to exports by a formal agreement. However, while the proportion of bilateral aid that was tied or partially tied in the early 1990s was something like 50% (Wagner, 2003), such practices were discouraged by various international organizations and, by the late 1990s, this form of aid had been reduced to 17.7% of the total (Tajoli, 1999).

When aid is not formally tied, there remain at least two reasons to expect a causal link from aid to trade. The first, presuming that aid increases income, is that an increase in the income of the recipients results in an increase in their imports (McGillivray and

[3] Our discussion here abstracts from the enormous theoretical literature on the link between transfers and trade. For an excellent survey see Brakman and van Marrewijk (1999).

Morrissey, 1998; Lahiri, Raimondos-Moller, 1997; Lloyd et al., 2000). The second is actually a collection of many different arguments that, for the purpose of this paper, can all be seen as establishing some kind of "economic and political link"[4] between donors and recipients. For instance, the recipient country may feel obligated to buy from the donor to maintain "good will" and secure the continuity of the aid flow (Wagner, 2003, page 158, also McGillivray and Morrissey, 1998, Lloyd et al., 2000). Alternatively, a donor may choose to finance development projects that require supplies from industries in which the donor is strong (Wagner, 2003). Besides, once the donor starts exporting to the recipient, there is an increase in the recipient's exposure to goods from the donor, which may result in future exports (Osei et al., 2004).

In contrast, there is also a line of research that favors the opposite direction of causality: from trade to aid. Most of this research consists of models that aim to explain the allocation of aid. In such models, donors prefer to allocate their aid to countries with which they have the greatest commercial links. This possibly reflects the influence of lobby groups (McGillivray and Morrissey, 1998; Lloyd et al., 2000; Osei et al., 2004; Morrissy et al., 1992).

There is also the possibility of no relationship (Osei et al.; 2004) or a contemporaneous relationship of these two variables (Osei et al., 2004), which could reflect the possibility that different factors determine both aid and trade levels (Wagner, 2003). Finally, the possibility of a negative relationship has also been raised. For instance, 1) trade may be used by donors as an indicator of a recipient's prosperity, so they reduce aid as trade increases (Osei et al., 2004); 2) a donor may use aid as a strategy to promote trade in the countries in which they have smaller market share (Lloyd et al, 2000); and 3) the substitution effect of aid: even if output growth generates an increase in the overall imports, the recipient can substitute among them and the bilateral trade flows may not increase (Osei et al., 2004).

[4] The expression "bilateral economical and political link" was used by Lloyd et al. (2000, pg. 109), and it is used throughout this paper.

Most of the empirical studies, find some evidence of aid causing trade, at least in part of the sample (e.g. Osei et al., 2004; Lloyd et al., 2000; McGillivray and Morrissey, 1998; Morrissey et al., 1992; and Wagner, 2003). We focus on the possibility of aid causing trade and, like Nilsson (1997) and Wagner (2003), we use the gravity equation to address this issue. More specifically, we include aid as a component of the "political, cultural and economical link" between donor and recipient as a determinant of trade. This kind of link features prominently in current work on the gravity equation, allowing us to take advantage of, and extend, innovations in gravity modeling.
The papers most closely related to ours are by Nilsson (1997) and Wagner (2003). Both apply standard, pre-AvW, gravity methods to study the link between aid and trade. Nilsson looks at EU aid for the period 1975-1992, where Wagner considers a broader range of donors and recipients for the period 1970-1990. As in our main specification, both authors estimate their models in logs, permitting them to interpret the estimated coefficients as elasticities. These elasticities can then be transformed into a direct measure of the impact of aid on trade. Nilsson estimates that \$1 of aid generates \$2.60 in exports from the donor to the recipient; while, in his preferred specification, Wagner estimates that \$1 of aid generates \$1.85 in exports from the donor to the recipient. Our estimate is dramatically less than either of these.[5]

However, it is also true that most studies find strong empirical evidence that trade causes aid, which implies that the econometric estimations performed in this paper are threatened by simultaneity bias.[6] To take account of this problem we follow the conventional approach and instrument for current levels of aid by their lags. Since at least some studies suggest that one lag period may not be sufficient to address this problem (e.g. Lloyd et al., 2000), we present an extensive analysis considering alternative number of lags.

[5] Note that, since both of these estimates are derived from gravity specifications that ignore the role of multilateral resistance, we expect our estimates of the effect of aid on trade to be smaller. See AvW (2004, pg. 714) for an excellent illustration of the way that not explicitly taking multilateral resistance into account produces upward bias in the estimates of trade costs (border barriers in that case).

[6] For instance, McGillivray and White (1993), Lloyd *et al*. (1998), Lloyd, *at al*, (2000), and Osei *et al*. (2004) find such empirical evidence.

The combination of empirical success and theoretical foundations has produced a new wave of gravity model research that is virtually tsunamic—threatening to overwhelm entire areas of empirical trade research. Not surprisingly, given its widespread use, a large number of theoretical, econometric and empirical issues have been raised. For the purposes of this paper, two are of particular significance: the appropriate modeling of trade costs; and whether developed and less developed countries are, in some well-specified sense (relative to the underlying model), different from one another. Before turning to a development of the theory and method used in this paper, we comment briefly on both.

Early work on the gravity model, deriving directly from Newton's universal law of gravitation, simply took distance as a measure of resistance to trade. While physical distance might well account for some resistance to trade, it was clear fairly early on that a variety of economically relevant (political and economic) factors were also associated with resistance: tariff and non-tariff protection; membership in a preferential trade agreement; membership in the GATT/WTO; common cultural (e.g. language), legal, or colonial links; etc. These have usually been introduced as fixed effects. One of the key insights from careful modeling of the relationship of trade barriers (broadly construed) to dyadic trade volumes is that what matters is the barriers to trade in the dyad *relative to* the average level of trade barriers (AvW 2003, 2004). The model developed here builds on this essential insight.

While it is certainly true that the gravity equation, in some form, can be rationalized by many varieties of trade model, it would appear that some version of monopolistic competition model is widely seen as the "natural" rationalization.[7] Given the use of this model to make sense of intra-industry trade, which is a major component of trade between highly industrialized countries but a modest component of less developed country trade, Helpman's (1987) finding, confirmed in great detail by Hummels and

[7] This perception may well have roots in early use of the gravity model to empirically represent/evaluate the Linder (1961) hypothesis of a link, based on taste similarity, between income similarity and trade volume. The growth of evidence on the major role of intra-industry trade, especially associated with the important empirical work of Grubel and Lloyd (1975) and Krugman's (1979, 1980) identification of monopolistic competition as a plausible account of that trade, further cemented this notion.

Levinsohn (1995), that the gravity equation performed well on samples of less developed countries as well as highly industrialized countries, was seen as something of a problem. Further empirical work seems to suggest, quite reasonably (and broadly consistent with Helpman and Krugman's, 1985, more general model embedding both endowment-based and variety-based trade), that the various models are differentially successful at explaining north-north, north-south, and south-south trade (e.g. Jensen, 2000; Evenett and Keller, 2002; Haveman and Hummels, 2004).

As a response to results of this sort, Helpman (1999) suggests a model with two kinds of countries: the South, which produces homogenous goods, and the North, which produces specialized ones. With the simplified assumption that all countries in the South are identical, he is able to determine the volume of trade between North and South and North and North[8]. However, as Haveman and Hummels (2004) argue, if producers are homogenous, bilateral trade is not determined since buyers are indifferent among sellers. Haveman and Hummels propose that trade costs provide a way out of this latter problem. We build directly on these insights in our attempt to include the South in the present model.

To summarize, we propose to estimate the gravity equation as proposed by AvW (2003) with the following modifications. First, we will include foreign aid among the "economic and political links" affecting the bilateral "resistance to trade" cost factor presented by AvW (2003). Second, the South will be assumed to produce a homogenous good. This inclusion, besides justifying the use of the gravity equation in this context, provides a simple explanation of zero trade flows between some country pairs.

[8] The working paper version of this paper (*NBER Working paper* #6752, 1998) develops the model in more detail. There Helpman assumes that this is an extreme condition since, without differences in the factor proportions in the South, there is no trade among southern countries. However, he argues that "this extreme formulation helps to make the main point (page 28)". We do not need to include this restrictive assumption in our model.

3) Modeling Foreign Aid in an Asymmetric Gravity Model

It makes sense to sort the channels through which foreign aid influences trade into direct and indirect effects[9]. The first works through the impact of foreign aid on income. However, since this impact depends on the total amount of aid, it is unlikely to be captured in the country pair estimations used here. The second is the impact of aid on the "bilateral political and economic link", discussed above, and is assumed here to be reflected in the "resistance to trade" cost factors, as cited in the gravity equation literature. We now model this second channel using AvW (2003).

Inserting the South and foreign aid in the AvW (2003) model.

AvW (2003) consider a model where each region j has identical CES utility function given by:

$$U_j = \left(\sum_i c_{ij}^{\sigma-1/\sigma} \right)^{\sigma/\sigma-1}$$

In AvW, every country i is endowed with a quantity of a differentiated good. In the above utility function, c_{ij} is the quantity of the good produced in region i and consumed in region j. Now consider the following modification: following the strategy of Helpman (1999), we assume that every country i is endowed with a quantity of good i, where Northern countries are endowed with one variety of a differentiated good and, as we shall see, Southern countries are endowed with a standardized good.[10]

The representative consumer has Cobb-Douglas preferences with respect to differentiated and homogenous goods. Differentiated goods are treated as in the AvW (2003) model:

[9] These terms were introduced by Wagner (2003)
[10] One could include many kinds of homogeneous goods but, as will be clear, the structure of costs assumed here would imply that each country would buy all kinds of homogenous goods from the same southern countries, so the contribution is not worth the additional mathematical complication.

that is, in CES fashion; while the consumer is indifferent to the origin of the homogenous good. The result is the following nested utility function[11]:

$$U_j = \left[\left(\sum_{i \in N} \left(c_{ij} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \right]^{\alpha} \left(\sum_{i \in S} c_{ij} \right)^{1-\alpha}. \tag{1}$$

Note that i indicates the origin of the good which is either in the North (N) or South (S). Since goods from the South are perfect substitutes, their exponent is one, and their total amount is like one single good in the utility function. This function is maximized given the budget constraint:

$$\sum_{i \in N} p_{ij} c_{ij} + \sum_{i \in S} p_{ij} c_{ij} = y_j \tag{2}$$

As in AvW (2003), assume that for each type of good, the price can be decomposed as:

$$p_{ij} = p_i t_{ij}$$

Where p is the price of the good in its own country and t is the "resistance to trade" cost factor between the two countries. In the context here this means that all homogeneous goods, independent of their origin, have same original price. Their final price then depends only on t, which varies for each country pair. Assume that t is larger than one when j is different from i and equals one when j equals i (country's own consumption). Denote the value of a demanded good by:

$$p_{ij} c_{ij} = x_{ij}$$

Given the symmetric way that the homogeneous good enters the utility function, demands can be shown to be:

$$x_{ij} = \left(1-\alpha\right) y_j \quad i \in S, \quad \text{if} \quad \tilde{t}_{ij} = \min_i \{t_{ij}\} \tag{3}$$

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[11] This is similar to the functional form proposed by Baier and Bergstrand (2002).

$$x_{ij} = \alpha \left(\frac{p_i t_{ij}}{P_j} \right)^{1-\sigma} y_j \quad i \in N \tag{4}$$

To develop some intuition about our extension, consider the extreme case of a World with three countries, a large one in the North and two small ones in the South[12]. In equilibrium, depending on the structure of t_{ij}, it may be the case that the Northern country buys from both Southern ones or, alternatively, that one Southern country buys from another and resells to the North. That is, each country will buy the homogeneous good only from the Southern country that supplies it for the cheapest price (presents the smallest resistance to trade) if, in equilibrium, it is enough for its consumption. If it is not, then the country will also buy from the second cheapest country and so on. This also implies that each country in the South consumes only its own homogeneous good.

The first contribution of this set up is that, as with AvW, the inclusion of barriers to trade explains why the predicted trade is inflated when compared to the observed pattern; and given the way the South is included, the model also accounts for the observations of zero trade in many country pairs. In the present framework, that may happen between a Northern and a Southern country and between Southern countries.

Production value in each country equals consumption value in the World:

$$y_i = \sum_{\substack{j \in N \\ j \in S}} x_{ij} = \sum_{\substack{j \in N \\ j \in S}} \alpha \left(\frac{p_i t_{ij}}{P_j} \right)^{1-\sigma} y_j, \quad i \in N \tag{5}$$

$$y_i = \sum_{j \in I} x_{ij} = \sum_{j \in I} (1-\alpha) y_j \quad i \in S \tag{6}$$

Where I is the set of countries that import the homogenous product from country i in the South. Define

$$\theta_j = {y_j}/{y^W} \tag{7}$$

[12] In such extreme case the assumption $p_{ij} = p_i t_{ij}$ is less likely to be true, but the argument is still valid.

The gravity equation can now be derived. Solving for $\left(p_i\right)^{1-\sigma}$ in the market clearing conditions and substituting in the demand equations we have, for *i* in the North:

$$x_{ij} = \frac{y_i y_j}{y^w}\left(\frac{t_{ij}}{P_j \Pi_i}\right)^{1-\sigma} \tag{8}$$

$$\Pi_i = \left[\sum_{\substack{j\in N\\ j\in S}}\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\theta_j\right]^{\frac{1}{1-\sigma}} \tag{9}$$

Since

$$P_j = \left[\sum_{i\in N}\left(p_i t_{ij}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{10}$$

Substituting $\left(p_i\right)^{1-\sigma}$ again yields:

$$P_j = \left[\frac{1}{\alpha}\sum_{i\in N}\left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}\theta_i\right]^{\frac{1}{1-\sigma}} \tag{11}$$

Note that the expressions above reflect the facts that: 1) each country in the North exports to every country in the North and in the South; and 2) each country in the South exports only to a subset of countries, possibly none (only internal consumption). Equation (9) is the multilateral resistance to export from the North (defined only for *i* in the North) and equation (11) is the multilateral resistance to import from the North (defined for *j* in the North or in the South).

The bilateral resistances to trade when countries in the North import from countries in the South are also crucial, but in a different way. Because each country in the North imports from only a subset of countries in the South (possibly one), it does not face a multilateral resistance to import but compares every bilateral one and picks the smallest. More specifically, for *i* in the South, solving for $(1-\alpha)$ in the market clearing condition for the South and substituting back into the expression for demand:

$$x_{ij} = \frac{y_i y_j}{\sum_{j \in I} y_j} \tag{12}$$

Consider again equation (11). In AvW's (2003) original model, the assumption of $t_{ij} = t_{ji}$ leads to $\Pi_i = P_i$ as a solution. Unfortunately, the distinction between South and North introduces an asymmetry in the model such that this simplification is not sensible anymore. Therefore, while it made sense for AvW to aggregate "export multilateral resistance" and "import multilateral resistance" into a general "multilateral resistance" in their model, this is not the case here.

To see how we handle this problem, note first that the $\{P_i\}$ are considered by AvW (2003) as a multilateral resistance index, and the authors do not encourage interpreting them as consumer prices index. As they state:

> "We will refer to the price indexes $\{P_i\}$ as "multilateral resistance variables as they depend on all bilateral resistances $\{t_{ij}\}$, including those not directly involving *i*. (…) While the P_i's are consumer price indexes in the model, that would not be a proper interpretation of these indexes more generally. One can derive exactly the same gravity equation and solution to the P_i when trade costs are not pecuniary. (…) In that case P_i no longer represents the consumer price index and the border barrier include home bias." (page 176)

Now, note that in the exports from *i* to *j*, P_j is an index related to all the goods that country *j* imports from the North and Π_i an index related to all the goods country *i* exports, *i* in the North. In addition, note how they are symmetrically defined by (9) and (11): P_j is a function of all the bilateral resistance terms of the countries *i* that country *j* imports from the North (relative to the export general resistance to export of each country *i*); and Π_i is a function of all the bilateral resistance terms of the countries *j* that country *i* export to (relative to the general import resistance of each country *j*). Therefore, that leads to our interpretation of P_j and Π_i as multilateral resistance to import from the North of country *j* and multilateral resistance to export of country *i* in the North respectively.

However, because these terms are nonlinear functions of each other and of t_{ij}, their interpretation is not as clear as we might desire. In addition, they require nonlinear estimation. Given that, we now apply the linearization technique proposed by B&B (2007). These authors use log-linear Taylor-series expansions to approximate the multilateral price terms in the AvW's (2003) model in order to be able to estimate it using OLS. We here follow their approach as closely as possible in our asymmetric North-South context.

Applying B&B's expansions to our model

In this section, we adapt 3 versions of Taylor expansions proposed by B&B (2007) to our model. To begin with, the center of the expansion is a frictionless world where $t = 1$. Next, the preceding case is generalized to a center where $t \geq 1$. This is the most general version, and we follow B&B (2007) and use it to compute the comparative static results.

However, it will be clear that the equations we obtain in this fashion contain the GDP-share-weighted (geometric) average of t_{ij} on the RHS. Therefore, introducing such an expansion in the gravity equation creates endogeneity bias (B&B, 2007, page 12). To address this problem, B&B (2007) use a third version of the Taylor series expansion in their estimations (although NOT in their comparative statics). In this version, the multilateral resistance to trade factors are expanded not only around a symmetric bilateral resistance to trade $t > 1$, but also around a symmetric GDP share $\theta = 1/N$ (equations 28 – 30, page 13). We adapt a similar procedure to our model, but the center in our case is t^{NN}, t^{NS}, θ^{N}, and θ^{S}. t^{NN} and t^{NS} represent trade barriers greater than one, the first between two countries in the North, the second between one country in the South and one in the North. Besides, θ^{N} and θ^{S} represent the average income share among countries in the North and in the South, that is:

$$\theta^N = \frac{\sum_{i\in N} \frac{y_j}{y^W}}{N^N} \text{ and } \theta^S = \frac{\sum_{i\in S} \frac{y_j}{y^W}}{N^S}, \tag{13}$$

where N^N is the number of countries in the North and N^S in the South.

Although we were able to adapt the procedure to our model, we encountered some shortcomings. First, as will be shown, to find a solution to this expansion, we need to approximate the arithmetic averages θ^N and θ^S to the geometric ones, that is, $\theta^N = \sqrt[N^N]{\prod_{i\in N}\theta_i}$ and $\theta^S = \sqrt[N^S]{\prod_{i\in S}\theta_i}$. This does not seem overly restrictive since all shares are positive, between zero and one. Second, the RHS of the obtained equation, although it does not contain the GDP-share-weighted (geometric) average of t_{ij} as before, it contains θ^N and θ^S (as B&B, 2007 contains θ = 1/N). Although to a much lesser degree (since they are almost constant over time), one may argue that θ^N and θ^S can introduce endogeneity bias. We comment on this point further in the empirical section. Nevertheless, we follow B&B (2007) and use this version of the Taylor expansion in our estimations.

The issue of price normalizations

Before we proceed to the expansions, a critical point must be emphasized. Both AvW's (2003) and B&B models are only solved for a given price normalization, even after the symmetry assumption. To see the implications of this, consider the solution proposed by AvW's (2003) where $\Pi_i = P_i$. As expected, it can be easily proved that, for any constant λ different from one, we can always re-normalize prices (multiplying every price by λ) without changing the real bundles. However, the equality $\Pi_i = P_i$ will no longer hold[13] despite that the symmetry assumption $t_{ij} = t_{ji}$ still does.

[13] See A&W (2003), footnote 12, page 175.

Although this can be seen as a weakness, it gives us great flexibility, as the next section shows. The reason is that we can choose any λ. In the asymmetric case of our model, choosing a convenient one will facilitate solving the Taylor expansion.

To make this point clear, in appendix 1 we illustrate how choosing a convenient λ allows us to expand AvW's (2003) original model without the asymmetry assumption. Since imposing symmetry is a particular case of the general expansion presented, this exposition shows that if we impose symmetry in addition to the price normalization proposed here, we are back to AvW's (2003) and B&B's case.

Three Alternative Taylor Expansions

Case 1: frictionless world (center at t = 1)

The equations to be expanded are

$$\begin{aligned} \Pi_i^{1-\sigma} &= \sum_{\substack{j\in N \\ j\in S}} \theta_j \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \\ P_j^{1-\sigma} &= \frac{1}{\alpha} \sum_{i\in N} \theta_i \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \end{aligned} \tag{14}$$

Note that, at the center,

$$\begin{aligned} \Pi_i^{1-\sigma} &= \sum_{\substack{j\in N \\ j\in S}} \theta_j \left(\frac{1}{P_j} \right)^{1-\sigma} \\ P_j^{1-\sigma} &= \frac{1}{\alpha} \sum_{i\in N} \theta_i \left(\frac{1}{\Pi_i} \right)^{1-\sigma} \end{aligned} \tag{15}$$

Multiplying the first equation by $\Pi_i^{\sigma-1}$:

$$1 = \sum_{\substack{j\in N\\ j\in S}} \theta_j \Pi_i^{1-\sigma} P_j^{1-\sigma} \tag{16}$$

The solution is $\Pi_i = P_j = 1$, for every *i* and *j*. Recall that $\alpha = \sum_{i\in N} \theta_i$, so the second equation is also satisfied[14].

It is useful to rewrite the equations to be expanded as:

$$\begin{aligned} e^{\ln \Pi_i^{1-\sigma}} &= \sum_{\substack{j\in N\\ j\in S}} e^{\ln \theta_j} e^{(1-\sigma)\ln t_{ij}} e^{(\sigma-1)\ln P_j} \\ e^{\ln P_j^{1-\sigma}} &= \frac{1}{\alpha} \sum_{i\in N} e^{\ln \theta_i} e^{(1-\sigma)\ln t_{ij}} e^{(\sigma-1)\ln \Pi_i} \end{aligned} \tag{17}$$

Given that, the first order log-linear Taylor series expansion of the first equation is:

$$\ln \Pi_i^{1-\sigma} + 1 = \sum_{\substack{j\in N\\ j\in S}} \theta_j + \sum_{\substack{j\in N\\ j\in S}} \theta_j (1-\sigma)\ln t_{ij} + \sum_{\substack{j\in N\\ j\in S}} \theta_j (\sigma - 1)\ln P_j \text{ or}$$

$$\ln \Pi_i^{1-\sigma} = \sum_{\substack{j\in N\\ j\in S}} \theta_j (1-\sigma)\ln t_{ij} + \sum_{\substack{j\in N\\ j\in S}} \theta_j (\sigma - 1)\ln P_j \tag{18}$$

Similarly, expanding the second equation, we have:

$$\begin{aligned} &\ln P_j^{1-\sigma} + 1 = \frac{1}{\alpha}\sum_{i\in N} \theta_i + \frac{1}{\alpha}\sum_{i\in N} \theta_i (1-\sigma)\ln t_{ij} + \frac{1}{\alpha}\sum_{i\in N} \theta_i (\sigma-1)\ln \Pi_i = \\ &= 1 + \frac{1}{\alpha}\sum_{i\in N} \theta_i (1-\sigma)\ln t_{ij} + \frac{1}{\alpha}\sum_{i\in N} \theta_i (\sigma-1)\ln \Pi_i \end{aligned} \tag{19}$$

[14] Indeed, the two equations are identical. To see that, note that, in the first equation, the RHS is constant for every *i*, and, in the second equation, RHS is constant for every *j*. Therefore, $\Pi_i = \Pi$ for every *i* and $P_j = P$ for every *j*.

Then, since $\alpha = \sum_{i \in N} \theta_i$:

$$\ln P_j^{1-\sigma} = \frac{1}{\sum_{i \in N} \theta_i} \left(\sum_{i \in N} \theta_i (1-\sigma) \ln t_{ij} + \sum_{i \in N} \theta_i (\sigma - 1) \ln \Pi_i \right) \tag{20}$$

Multiplying both sides of equation (18) by θ_i we have:

$$\theta_i \ln \Pi_i^{1-\sigma} = \sum_{\substack{j \in N \\ j \in S}} \theta_j (1-\sigma) \ln t_{ij} \theta_i + \sum_{\substack{j \in N \\ j \in S}} \theta_j (\sigma - 1) \ln P_j \theta_i \tag{21}$$

Summing across *i* in the North:

$$\sum_{i \in N} \theta_i \ln \Pi_i^{1-\sigma} = \sum_{i \in N} \sum_{\substack{j \in N \\ j \in S}} \theta_j \theta_i (1-\sigma) \ln t_{ij} + \sum_{i \in N} \theta_i \sum_{\substack{j \in N \\ j \in S}} \theta_j (\sigma - 1) \ln P_j \tag{22}$$

Similarly, multiplying equation (20) by θ_j:

$$\theta_j \ln P_j^{1-\sigma} = \frac{1}{\sum_{i \in N} \theta_i} \left(\sum_{i \in N} \theta_i (1-\sigma) \ln t_{ij} \theta_j + \sum_{i \in N} \theta_i (\sigma - 1) \ln \Pi_i \theta_j \right) \tag{23}$$

Summing across j both in the North and in the South:

or

$$\sum_{\substack{j \in N \\ j \in S}} \theta_j \ln P_j^{1-\sigma} = \frac{1}{\sum_{i \in N} \theta_i} \left(\sum_{\substack{j \in N \\ j \in S}} \sum_{i \in N} \theta_j \theta_i (1-\sigma) \ln t_{ij} + \sum_{\substack{j \in N \\ j \in S}} \theta_j \sum_{i \in N} \theta_i (\sigma - 1) \ln \Pi_i \right) \tag{24}$$

Note that, since $\sum_{\substack{j\in N\\ j\in S}}\theta_j = 1$, equations (22) and (24) are identical. Consider a price normalization such as:

$$\sum_{i\in N}\theta_i \ln \Pi_i^{1-\sigma} = \sum_{i\in N}\theta_i \sum_{\substack{j\in N\\ j\in S}}\theta_j \ln P_j^{1-\sigma} \tag{25}$$

To show that such price normalization is possible, note that the shares do not change with any price normalizations. Besides, it is proved in appendix 2 that, for any given equilibrium and any given λ, if we multiply every price p_i by λ, we have the same real equilibrium (real bundles), but each P_j is multiplied by λ and each Π_i is multiplied by $1/\lambda$. Let the multilateral resistance to trade factors in a given equilibrium (with any price normalization) be given by Π_i and P_j. Consider now a new price normalization and let the same indexes be denoted by $\widetilde{P}_j = \lambda P_j$ and $\widetilde{\Pi}_j = \Pi_j / \lambda$. Given that, for a given equilibrium, we want a price re-normalization such as:

$$\left(\prod_{\substack{j\in N\\ j\in S}}\widetilde{P}_j^{\theta_j}\right)^{\sum_{i\in N}\theta_i} = \prod_{i\in N}\widetilde{\Pi}_i^{\theta_i} \quad \text{or}$$

$$\left(\prod_{\substack{j\in N\\ j\in S}}\left(\lambda P_j\right)^{\theta_j}\right)^{\sum_{i\in N}\theta_i} = \prod_{i\in N}\left(\frac{\Pi_i}{\lambda}\right)^{\theta_i} \tag{26}$$

Dividing both sides by λ^{α}:

$$\left(\prod_{\substack{j\in N\\ j\in S}}\left(P_j\right)^{\theta_j}\right)^{\sum_{i\in N}\theta_i} = \lambda^{-\alpha}\prod_{i\in N}\Pi_i^{\theta_i}\lambda^{-\theta_i} = \left(\lambda^{-\sum_{i\in N}\theta_i}\lambda^{-\alpha}\right)\prod_{i\in N}\Pi_i^{\theta_i} = \left(\lambda^{-2\sum_{i\in N}\theta_i}\right)\prod_{i\in N}\Pi_i^{\theta_i} \tag{27}$$

Hence,

$$\lambda = \left(\frac{\left(\prod_{\substack{j\in N \\ j\in S}} \left(P_j\right)^{\theta_j} \right)^{\sum_{i\in N}\theta_i}}{\left(\prod_{i\in N} \left(\Pi_i\right)^{\theta_i} \right)} \right)^{\frac{1}{-2\sum_{i\in N}\theta_i}} \tag{28}$$

Therefore, for a given equilibrium, we can always normalize prices by the λ above and get the desired result. By (25) we have:

$$\sum_{i\in N} \theta_i \ln \Pi_i^{1-\sigma} = \frac{1}{2} \sum_{i\in N} \sum_{\substack{j\in N \\ j\in S}} \theta_j \theta_i (1-\sigma) \ln t_{ij} = \sum_{i\in N} \theta_i \sum_{\substack{j\in N \\ j\in S}} \theta_j (1-\sigma) \ln P_j \tag{29}$$

Substituting the above equation back in (18):

$$\ln \Pi_i^{1-\sigma} = \sum_{\substack{j\in N \\ j\in S}} \theta_j (1-\sigma) \ln t_{ij} - \frac{1}{2\sum_{i\in N}\theta_i} \sum_{i\in N} \sum_{\substack{j\in N \\ j\in S}} \theta_j \theta_i (1-\sigma) \ln t_{ij} \tag{30}$$

Similarly

$$\ln P_j^{1-\sigma} = \frac{1}{\sum_{i\in N}\theta_i} \left(\sum_{i\in N} \theta_i (1-\sigma) \ln t_{ij} - \frac{1}{2} \sum_{i\in N} \sum_{\substack{j\in N \\ j\in S}} \theta_i \theta_j (1-\sigma) \ln t_{ij} \right) \tag{31}$$

Case 2: Center at t > 1 – version for comparative statics

Divide both sides of both equations to be expanded (14) by $t^{1/2}$:

$$\frac{\Pi_i}{t^{1/2}} = \left(\sum_{\substack{j \in N \\ j \in S}} \theta_j \left(\frac{t_{ij}/t}{P_j/t^{1/2}} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

$$\frac{P_j}{t^{1/2}} = \left(\frac{1}{\alpha} \sum_{i \in N} \theta_i \left(\frac{t_{ij}/t}{\Pi_i/t^{1/2}} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{32}$$

Define:

$$\tilde{t}_{ij} = \frac{t_{ij}}{t}$$

$$\tilde{P}_j = \frac{P_j}{t^{1/2}} \tag{33}$$

$$\tilde{\Pi}_i = \frac{\Pi_i}{t^{1/2}}$$

Then we can rewrite (14) as:

$$\tilde{\Pi}_i^{1-\sigma} = \sum_{\substack{j \in N \\ j \in S}} \theta_j \left(\frac{\tilde{t}_{ij}}{\tilde{P}_j} \right)^{1-\sigma}$$

$$\tilde{P}_j^{1-\sigma} = \frac{1}{\alpha} \sum_{i \in N} \theta_i \left(\frac{\tilde{t}_{ij}}{\tilde{\Pi}_i} \right)^{1-\sigma} \tag{34}$$

Since, at the center, $\tilde{t} = \frac{t}{t} = 1$, the system above is similar to the one in the frictionless case and we have:

$$\ln \tilde{\Pi}_i^{1-\sigma} = \sum_{\substack{j \in N \\ j \in S}} \theta_j (1-\sigma) \ln \tilde{t}_{ij} - \frac{1}{2\sum_{i \in N} \theta_i} \sum_{i \in N} \sum_{\substack{j \in N \\ j \in S}} \theta_j \theta_i (1-\sigma) \ln \tilde{t}_{ij} \tag{35}$$

$$\ln \tilde{P}_j^{1-\sigma} = \frac{1}{\sum_{i \in N} \theta_i} \left(\sum_{i \in N} \theta_i (1-\sigma) \ln \tilde{t}_{ij} - \frac{1}{2} \sum_{i \in N} \sum_{\substack{j \in N \\ j \in S}} \theta_i \theta_j (1-\sigma) \ln \tilde{t}_{ij} \right) \tag{36}$$

Now note that:

$$\ln \widetilde{\Pi}_i = \ln \Pi_i - \frac{1}{2} \ln t ,$$

$$\ln \widetilde{P}_i = \ln P_i - \frac{1}{2} \ln t \text{, and}$$

$$\ln \widetilde{t}_{ij} = \ln t_{ij} - \ln t$$

Then:

$$\begin{aligned}(1-\sigma)\left(\ln \Pi_i - \frac{1}{2}\ln t\right) = \sum_{\substack{j\in N\\ j\in S}} \theta_j (1-\sigma)\ln t_{ij} - \sum_{\substack{j\in N\\ j\in S}} \theta_j (1-\sigma)\ln t - \frac{1}{2\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}} \theta_j\theta_i(1-\sigma)\ln t_{ij} + \\ + \frac{1}{2\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}} \theta_j\theta_i(1-\sigma)\ln t\end{aligned} \tag{37}$$

Therefore, we are back to the previous case:

$$\ln \Pi_i^{1-\sigma} = \sum_{\substack{j\in N\\ j\in S}} \theta_j (1-\sigma)\ln t_{ij} - \frac{1}{2\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}} \theta_j\theta_i(1-\sigma)\ln t_{ij} \tag{38}$$

Similarly:

$$\begin{aligned}(1-\sigma)\left(\ln P_j - \frac{1}{2}\ln t\right) = \frac{1}{\sum_{i\in N}\theta_i}\Bigg(\sum_{i\in N}\theta_i(1-\sigma)\ln t_{ij} - \sum_{i\in N}\theta_i(1-\sigma)\ln t \\ - \frac{1}{2}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_i\theta_j(1-\sigma)\ln t_{ij} + \frac{1}{2}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_i\theta_j(1-\sigma)\ln t\Bigg)\end{aligned} \tag{39}$$

Resulting in:

$$\ln P_j^{1-\sigma} = \frac{1}{\sum_{i\in N}\theta_i}\left(\sum_{i\in N}\theta_i(1-\sigma)\ln t_{ij} - \frac{1}{2}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_i\theta_j(1-\sigma)\ln t_{ij}\right) \tag{40}$$

Case 3: Center at t^{NN}, t^{NS}, θ^N, and θ^S - Version for empirical estimations

In this version, in the center, we obtain Π_N, P_N, P_S [15]:

$$\Pi_N^{\;1-\sigma} = \left[N^N\theta^N\left(\frac{t^{NN}}{P_N}\right)^{1-\sigma} + N^S\theta^S\left(\frac{t^{NS}}{P_S}\right)^{1-\sigma}\right] \tag{41}$$

$$P_N^{\;1-\sigma} = \left[\left(\frac{t^{NN}}{\Pi_N}\right)^{1-\sigma}\frac{\theta^N N^N}{\alpha}\right] = \left(\frac{t^{NN}}{\Pi_N}\right)^{1-\sigma} \tag{42}$$

$$P_S^{\;1-\sigma} = \left(\frac{t^{NS}}{\Pi_N}\right)^{1-\sigma} \tag{43}$$

Also, note that

$$\left(t^{NS}\right)^{1-\sigma} P_S^{\;\sigma-1} = \left(t^{NN}\right)^{1-\sigma} P_N^{\;\sigma-1} = \Pi_N^{1-\sigma} \tag{44}$$

Rewriting equation the first equation (14) as:

$$e^{(1-\sigma)\ln\Pi_i} = \sum_{j\in N} e^{\ln\theta_j} e^{(\sigma-1)\ln P_j} e^{(1-\sigma)\ln t_{ij}} + \sum_{j\in S} e^{\ln\theta_j} e^{(\sigma-1)\ln P_j} e^{(1-\sigma)\ln t_{ij}} \tag{45}$$

[15] To see that, substitute t^{NN}, t^{NS}, θ^N, *and* θ^S in the first equation (14) and note that, at this center, the RHS becomes constant for every Π_i. Therefore, we call it Π_N. P_N and P_S are similarly obtained.

Using (42), (43), and the fact that $N^N\theta^N + N^S\theta^S = 1$, the Taylor expansion is:

$$\begin{aligned}\ln \Pi_i^{1-\sigma} = \theta^N \left[\sum_{j\in N} \left(\ln\theta_j + (1-\sigma)\ln t_{ij} + \ln P_j^{\sigma-1} \right) \right] + \\ +\theta^S \left[\sum_{j\in S} \left(\ln\theta_j + (1-\sigma)\ln t_{ij} + \ln P_j^{\sigma-1} \right) \right] - \theta^N N^N \ln\theta^N - \theta^S N^S \ln\theta^S\end{aligned} \tag{46}$$

Similarly, the second equation in (14) can be expanded as:

$$\ln P_j^{1-\sigma} = \frac{1}{N^N}\left[\sum_{i\in N} \left(\ln\theta_i + (1-\sigma)\ln t_{ij} + \ln \Pi_i^{\sigma-1} \right) \right] - \ln\theta^N \tag{47}$$

Summing across every country in the North we have:

$$\begin{aligned}\sum_{i\in N} \ln \Pi_i^{1-\sigma} = \theta^N N^N \left[\sum_{j\in N} \left(\ln\theta_j + \ln P_j^{\sigma-1} \right) \right] + \theta^S N^N \left[\sum_{j\in S} \left(\ln\theta_j + \ln P_j^{\sigma-1} \right) \right] + \\ \theta^N \sum_{i\in N}\sum_{j\in N} (1-\sigma)\ln t_{ij} + \theta^S \sum_{i\in N}\sum_{j\in S} (1-\sigma)\ln t_{ij} - N^N\theta^N N^N \ln\theta^N - N^N\theta^S N^S \ln\theta^S\end{aligned} \tag{48}$$

And

$$\sum_{j\in N} \ln P_j^{1-\sigma} = \left[\sum_{i\in N} \left(\ln\theta_i + \ln \Pi_i^{\sigma-1} \right) \right] + \frac{1}{N^N} \sum_{i\in N}\sum_{j\in N} \ln t_{ij}^{1-\sigma} - N^N \ln\theta^N \tag{49}$$

Similarly, summing for every country in the South:

$$\sum_{j\in S} \ln P_j^{1-\sigma} = \frac{N^S}{N^N}\left[\sum_{i\in N} \ln\theta_i + \ln \Pi_i^{\sigma-1} \right] + \frac{1}{N^N} \sum_{i\in N}\sum_{j\in S} (1-\sigma)\ln t_{ij} - N^S \ln\theta^N \tag{50}$$

Consider the previous system of equations. We have three equations and three unknowns, $\sum_{i\in N}\ln\Pi_i^{1-\sigma}$, $\sum_{j\in N}\ln P_j^{1-\sigma}$ and $\sum_{j\in S}\ln P_j^{1-\sigma}$. In order to achieve an approximate solution, we must impose the restriction that the arithmetic averages θ^N and θ^S are close enough to the geometric ones, that is, $\theta^N = \sqrt[N^N]{\prod_{i\in N}\theta_i}$ and $\theta^S = \sqrt[N^S]{\prod_{i\in S}\theta_i}$. Those assumptions imply that $\ln\prod_{i\in N}\theta_i = \sum_{i\in N}\ln\theta_i = N^N\ln\theta^N$ and that $\ln\prod_{i\in S}\theta_i = \sum_{i\in S}\ln\theta_i = N^S\ln\theta^S$. To see why we need this restriction, multiply both sides of equation (49) by $N^N\theta^N$, both sides of equation (50) by $N^N\theta^S$, and sum them up. We obtain that:

$$N^N\theta^N\sum_{j\in N}\ln P_j^{1-\sigma} + N^N\theta^S\sum_{j\in S}\ln P_j^{1-\sigma} = \sum_{i\in N}\ln\Pi_i^{\sigma-1} + \sum_{i\in N}\ln\theta_i + \theta^N\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma}$$
$$\theta^S\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} - N^N N^N\theta^N\ln\theta^N - N^N N^S\theta^S\ln\theta^N$$

Multiplying by (-1), and substituting into equation (48), we have:

$$\sum_{i\in N}\ln\Pi_i^{1-\sigma} = \sum_{i\in N}\ln\Pi_i^{1-\sigma} - \sum_{i\in N}\ln\theta_i - \theta^N\sum_{i\in N}\sum_{j\in N}\ln t_{ij}^{1-\sigma} - \theta^S\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} + N^N\theta^N N^N\ln\theta^N + N^N\theta^S N^N\ln\theta^N +$$
$$+ N^N\theta^N\sum_{i\in N}\ln\theta_i + N^N\theta^S\sum_{i\in S}\ln\theta_i + \theta^N\sum_{i\in N}\sum_{j\in N}\ln t_{ij}^{1-\sigma} + \theta^S\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} - N^N\theta^N N^N\ln\theta^N - N^N\theta^S N^N\ln\theta^S$$

Using $N^N\theta^N + N^S\theta^S = 1$, we can see that the equality above is true as long as:

$$\frac{\prod_N \theta_i}{\left(\theta^N\right)^{N^N}} = \frac{\prod_S \theta_i}{\left(\theta^S\right)^{N^S}}$$

Given that, after using the approximation of the arithmetic and geometric averages to simplify the systems of equations we obtain:

$$\sum_{i\in N}\Pi_i^{1-\sigma} = \theta^N N^N \sum_{j\in S}\ln P_j^{\sigma-1} + \theta^N \sum_{i\in N}\sum_{j\in N}\ln t_{ij}^{1-\sigma} + \theta^S \sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} \tag{51}$$

$$\sum_{j\in N}\ln P_j^{1-\sigma} = \sum_{i\in N}\ln \Pi_i^{\sigma-1} + \frac{1}{N^N}\sum_{i\in N}\sum_{j\in N}\ln t_{ij}^{1-\sigma} \tag{52}$$

$$\sum_{j\in S}\ln P_j^{1-\sigma} = \frac{N^S}{N^N}\sum_{i\in N}\ln \Pi_i^{\sigma-1} + \frac{1}{N^N}\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} \tag{53}$$

The Solution to this system is[16]:

$$\sum_{i\in N}\ln \Pi_i^{1-\sigma} = 0 \tag{54}$$

$$\sum_{j\in N}\ln P_j^{1-\sigma} = \frac{1}{N^N}\sum_{i\in N}\sum_{j\in N}\ln t_{ij}^{1-\sigma} \tag{55}$$

$$\sum_{j\in S}\ln P_j^{1-\sigma} = \frac{1}{N^N}\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} \tag{56}$$

Substituting back in equations (46) and (47), the Northern country *i*'s multilateral resistance to export can be expressed as:

$$\sum_{i\in N}\Pi_i^{1-\sigma} = \theta^N \sum_{j\in N}\ln t_{ij}^{1-\sigma} + \theta^S \sum_{j\in S}\ln t_{ij}^{1-\sigma} - \frac{\theta^N}{N^N}\sum_{i\in N}\sum_{j\in N}\ln t_{ij}^{1-\sigma} - \frac{\theta^S}{N^N}\sum_{i\in N}\sum_{j\in S}\ln t_{ij}^{1-\sigma} \tag{57}$$

[16] As mentioned in A&W (2003), footnote 12, page 175, their symmetric solution implies a price normalization. The B&B (2006) expansion carries on this price normalization, especially after expressing $P_j^{1-\sigma}$ as a function of t_{ij}, since t_{ij} are exogenous variables, and therefore, given. Our solution also implies a price normalization. As showed in appendix 2, none of these normalizations is problematic since they do not change the real bundles.

O the other hand, the multilateral resistance to import from the North, for j in the North or in the South, is given by:

$$\ln P_j^{1-\sigma} = \frac{1}{N^N} \sum_{i \in N} \ln t_{ij}^{1-\sigma} \tag{58}$$

Substituting back in the gravity equation derived for exports from the North, we have:

$$\begin{aligned} \tilde{x}_{ij} &= \beta_0 + \ln t_{ij} \\ &-(1-\sigma)\left[\theta^S \sum_{j \in S} \ln t_{ij} - \frac{\theta^S}{N^N} \sum_{i \in N} \sum_{j \in S} \ln t_{ij}\right] \\ &-(1-\sigma)\left[\theta^N \sum_{j \in N} \ln t_{ij} - \frac{\theta^N}{N^N} \sum_{i \in N} \sum_{j \in N} \ln t_{ij}\right] \\ &-(1-\sigma)\left[\frac{1}{N^N} \sum_{i \in N} \ln t_{ij}\right] \end{aligned} \tag{59}$$

Where $\beta_0 = -\ln Y^W$ is constant across country pairs and is substituted by time fixed effects; and $\tilde{x}_{ij} = \ln x_{ij} - \ln y_i - \ln y_j$.

4) Estimation Procedures

The resistance to trade term is not directly observable, so it must be substituted for by observable variables. As common in the gravity equation literature, we include: 1) the distance between the political capitals of the two countries; 2) a dummy that takes value of unity if the two countries share the same border; 3) a dummy that takes value of unity if countries have a common official language; and, the focus of our analysis, 4) foreign aid. Note that, unlike distance, border and language, how foreign aid is related to trade is a more complex question. Different channels have been proposed and those affect the decision of how many and which lags of aid should be included in the specification. We return to this question in the next section.

As AvW (2003) and most authors in the field do, we assume the following functional form for trade barriers:

$$t_{ij} = aid^{\beta_1} dist_{ij}^{\beta_2} e^{\beta_3 border_{ij}} e^{\beta_4 lang_{ij}} \tag{60}$$

Following B&B (2006), and Egger and Nelson (2007), we transform foreign aid as follows:

$$\begin{aligned}
&(1-\sigma)\ln\overline{aid}_{ij} = (1-\sigma)\ln aid_{ij} - \\
&-(1-\sigma)\left[\theta^S \sum_{j\in S}\ln aid_{ij} - \frac{\theta^S}{N^N}\sum_{i\in N}\sum_{j\in S}\ln aid_{ij}\right] - \\
&-(1-\sigma)\left[\theta^N \sum_{j\in N}\ln aid_{ij} - \frac{\theta^N}{N^N}\sum_{i\in N}\sum_{j\in N}\ln aid_{ij}\right] - \\
&-(1-\sigma)\left[\frac{1}{N^N}\sum_{i\in N}\ln aid_{ij}\right]
\end{aligned} \tag{61}$$

Note that $\overline{dist}$ is defined in a similar way. The dummy variables, on the other hand, are transformed in levels:

$$\begin{aligned}
&(1-\sigma)\overline{lang}_{ij} = (1-\sigma)lang_{ij} - \\
&-(1-\sigma)\left[\theta^S \sum_{j\in S} lang_{ij} - \frac{\theta^S}{N^N}\sum_{i\in N}\sum_{j\in S} lang_{ij}\right] - \\
&-(1-\sigma)\left[\theta^N \sum_{j\in N} lang_{ij} - \frac{\theta^N}{N^N}\sum_{i\in N}\sum_{j\in N} lang_{ij}\right] - \\
&-(1-\sigma)\left[\frac{1}{N^N}\sum_{i\in N} lang_{ij}\right]
\end{aligned} \tag{62}$$

and $\overline{border}$ is defined similarly.

For most country pairs, the foreign aid variable takes the value of zero. A very small number is added to it so that we can use it in logarithmic form. The purpose is to facilitate the interpretation of the coefficient especially when compared to the GDPs' coefficients (both variables are estimated in the same scale). To check for sensitivity, we also transform aid as in equation (62) and redo the estimations with zero aid flows.

The final equation to be estimated is then:

$$\tilde{x}_{ij} = \beta_0 + (1-\sigma)\beta_1 \ln \overline{aid}_{ij} + (1-\sigma)\beta_2 \ln \overline{dist} + (1-\sigma)\beta_3 \overline{border} + (1-\sigma)\beta_4 \overline{lang} + \varepsilon_{ij} \quad (63)$$

where i is in the North.

Sources of data

The foreign aid data are from the International and Development Statistics – OECD (2005). The GDP were obtained from World Bank (World Development Indicators – 2002). The trade data are available from Feenstra's web page.[17] Finally, distance, language, and border data were obtained from the Centre D'Etudes Prospectives Et D'Informations Internacionales (CEPII).[18]

Each dataset has a different list of countries and adopt different codes. The countries that have a value for at least one year of every variable are kept in the merged dataset. Sometimes countries and regions are aggregated in different ways and the data are adapted to follow Feenstra's codes and aggregation as closely as possible. The final time range, after the aggregation of datasets, is from 1962 to 2000.

The countries are classified as belonging to the North following the World Bank classification of "high income countries", that is, countries with 2005 GNI per capita

[17] (http://www.econ.ucdavis.edu/faculty/fzfeens/)
[18] (http://www.cepii.fr/anglaisgraph/bdd/distances.htm)

greater or equal to $10,726.00 dollars.[19] This classification is also used by the International and Development Statistics – OECD (2005) dataset. Since GNI per capita is not available for every country, sometimes this decision was based on other available information. Every other country, not considered belonging to the North, was considered belonging to the South.

5) Estimation Results and Discussion

Choosing the appropriate specification for foreign aid.

The choice of an econometric specification for foreign aid, that is, how many and which lags to include, is a tricky problem. One must consider 1) through what channels aid affects trade; and 2) the possibility of simultaneity, that is, trade affecting aid.

Recall the many arguments mentioned in the introduction that justify why we model aid as a "negative trade barrier", or as a "political link" or "political proximity" between countries. Those include: 1) tied aid (Wagner, 2003); 2) the effect of an increase in income (McGillivray and Morrissey, 1998; Lahiri, Raimondos-Moller, 1997; Lloyd et al., 2000); 3) that a donor may choose to finance development projects that require supplies from industries in which the donor is strong (Wagner, 2003); 4) the recipient country may feel obligated to buy from the donor to maintain "good will" and secure the continuity of the aid flow (Wagner, 2003, page 158, also McGillivray and Morrissey, 1998, Lloyd et al., 2000); 5) once the donor starts exporting to the recipient, there is an increase in the recipient's exposure to goods from the donor, which may result in future exports (Osei et al., 2004).

Considering these possible channels together, one should expect two things. First, that it may take some time before aid fully affects trade[20] . If the argument is that donors choose

[19] See World Bank website at the Data and Statistics section (http://www.worldbank.org)

[20] As mentioned by Greene, chapter 19: "In modeling the response of economic variables to policy stimuli, it is expected that there will be possibly long lags between policy changes and their impacts. The length of

to finance development projects that require supplies from industries in which the donor is strong, such projects will take time to mature. If the effect of aid is through income, it will take time for the donated resources to be converted to imports (unless aid is tied). The same can be said about the recipient trying to secure continuity of aid flow and the recipient's exposure to goods produced by the donor.

Second, one should expect that the effects of aid to last. The dynamic behavior of income is extensively studied. Projects that require supplies from industries in which the donor is strong are also supposed to last. Similarly, the "maintenance of good will" and the exposure to markets are not expected to suddenly vanish.

These two points imply that we must include different lags of aid, and we let the data determine which ones. Therefore, we start this section investigating this question. That allows us to concurrently tackle the issue of simultaneity between aid and trade since proxying aid with its own lags is a way to deal with it.

In the task of determining the number of relevant lags in the model, the safest strategy is the general-to-specific one: include more lags than one would reasonably believe necessary. However, different lags of foreign aid are severely collinear, which is problematic for the estimations. That can be clearly seen in the next table.

Table 1: Correlation between various lags of aid

lag between changes in monetary policy and its impact on important economic variables such as output and investments has been a subject of analysis for several decades".

	lag 1	lag 2	lag 3	lag 4	lag 5	lag 6	lag 7	lag 8	lag 9	lag 10
lag 1	1.000									
lag 2	0.923	1.000								
lag 3	0.898	0.922	1.000							
lag 4	0.876	0.896	0.921	1.000						
lag 5	0.857	0.874	0.895	0.920	1.000					
lag 6	0.837	0.854	0.871	0.893	0.919	1.000				
lag 7	0.819	0.835	0.852	0.870	0.892	0.918	1.000			
lag 8	0.801	0.815	0.832	0.850	0.868	0.889	0.917	1.000		
lag 9	0.782	0.795	0.811	0.829	0.846	0.865	0.887	0.916	1.000	
lag 10	0.764	0.777	0.791	0.808	0.825	0.843	0.863	0.886	0.915	1.000

Note:

1. Aid in logarithmic form (small value summed when laid level is zero). Multilateral effects included as described by equation 59.

As a result, the coefficients are highly sensitive to the inclusion of lags and have high standard errors even when they are jointly significant. In the next table, we show the coefficients and the p-values when we include from one to 10 lags. The model is described in equation (63). Note that multilateral effects are taken into account. Shaded area means significant at least at 90% level and expected sign.

Table 2: Coefficients and p-values of aid when different numbers of aid lags are included

Lags of Aid	1lag	1 - 2 lags	1 - 3 lags	1 - 4 lags	1 - 5 lags	1 - 6 lags	1 - 7 lags	1 - 8 lags	1 - 9 lags	1 - 10 lags
lag 1	0.011	0.005	0.003	0.002	0.001	0.001	0.000	-0.001	-0.001	-0.002
p-value	0.000	0.000	0.021	0.166	0.400	0.633	0.863	0.457	0.263	0.099
lag 2		0.007	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
p-value		0.000	0.012	0.060	0.115	0.156	0.126	0.202	0.275	0.297
lag 3			0.006	0.004	0.003	0.003	0.003	0.003	0.003	0.003
p-value			0.000	0.010	0.025	0.045	0.043	0.030	0.064	0.080
lag 4				0.005	0.003	0.003	0.003	0.003	0.003	0.003
p-value				0.000	0.045	0.048	0.054	0.054	0.034	0.061
lag 5					0.004	0.002	0.002	0.002	0.002	0.003
p-value					0.005	0.139	0.127	0.123	0.111	0.072
lag 6						0.002	0.002	0.002	0.002	0.002
p-value						0.060	0.184	0.252	0.193	0.165
lag 7							0.001	0.000	0.000	0.000
p-value							0.507	0.943	0.951	0.942
lag 8								0.002	0.002	0.002
p-value								0.132	0.244	0.171
lag 9									0.001	0.001
p-value									0.674	0.416
lag 10										-0.001
p-value										0.544
Sum of all coefficients	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Obs	123907	121876	119821	117515	115165	112723	110144	107495	104714	101747
R squared	0.224	0.219	0.214	0.208	0.203	0.198	0.193	0.188	0.182	0.175

Note: distance, dummy for border, dummy for common language, and dummies for years included. Aid and distance in logarithmic form (small value summed when aid level is zero). Multilateral effects included as described by equation 59. Shaded area means significance at 90% level and expected sign. The p-value of the joint significance of aid (all lags included) is, in every case, 0.000.

Although the results above are compromised due to multicollinearity, note some interesting features in the previous table. First, the p-value of the joint significance of aid is, in every case, 0.000. Second, when many lags are included, the significant coefficients are concentrated in between lags 3 and 6. Third, in the different specifications, the aid coefficients sum more or less to 0.01. Compare these sums to the coefficients obtained when different lags, but one at a time, are included in the model. Those are presented in the next table.

Table 3: Estimations including a different lag of aid at a time

Including only lag:	Coefficient	p-value	R2	Obs
lag 1	0.0112	0.0000	0.2236	123907
lag 2	0.0115	0.0000	0.2187	121876
lag 3	0.0117	0.0000	0.2136	119821
lag 4	0.0118	0.0000	0.2082	117515
lag 5	0.0117	0.0000	0.2030	115165
lag 6	0.0115	0.0000	0.1978	112723
lag 7	0.0111	0.0000	0.1921	110144
lag 8	0.0111	0.0000	0.1872	107495
lag 9	0.0109	0.0000	0.1808	104714
lag 10	0.0104	0.0000	0.1738	101747

Note:

1. Distance, dummy for border, dummy for common language, and dummies for years included. Aid and distance in logarithmic form (small value summed when laid level is zero). Multilateral effects included as described by equation (61).

Note that the coefficients in the table above are very close to each other and very close to the sum of coefficients in table 2. Analyzing the last two tables simultaneously, we can see that, since aid is highly multicollinear, to include more than one lag means to include the same information more than once. Note also that the R squared when more than one lag is included does not differ substantially from the above (compare table 2 with table

3). In addition, the coefficients of the other variables of interest (distance, dummy for common language, dummy for common border) do not alter significantly (not reported). Finally, the Akaike and Schwartz criterion both favor the inclusion off all 10 lags when more than one lag is included, and the tenth lag when only one lag at a time is included.

Considering all these factors together, we decided to use as a proxy of the negative "trade barrier" caused by foreign aid its fifth lag. We are confident in our choice since: 1) the lag we choose (even if more than one) does not substantially interfere the comparative statistics results since the coefficients (or their sum) are very similar; 2) the total significance of foreign aid is not affected; 3) we are controlling for the possibility of simultaneity between aid and trade since 5 year is a fairly distant lag; and 4) we are not excluding as many observations as we would if we had chosen the 10th lag and are not restricting our model to only the most current observations.

Main Estimation Procedure Results

The following results refer to the estimations of the exports from the North destined both to the North and to the South. Exports proceeding from the South, according to our model, are not determined by equation (59) but by a more complex system. Note that, although the trade resistance terms are crucial when determining from which country the homogenous good will be imported, they do not enter directly in the gravity equation (12). Since our focus is on the effect of foreign aid on donor exports, and because Southern countries are rarely donors, we do not develop a methodology for the estimation of (12).

We start presenting in Table 1 the results of the estimation of equation (59).[21] The first column presents our main estimation procedure where the coefficients are obtained by OLS[22]. All variables are significant and have the expected signs. In particular, note that the presence of foreign aid increases trade.

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[21] Year fixed effects are included in every estimation.
[22] All cases are estimated by OLS except when otherwise stated.

For completeness, the next column presents the results for the fixed effect estimation. In this procedure, variables that are constant across country pairs (such as distance and the dummy variables for border and language) must be dropped. By (59), however, we see that, when the multilateral terms are included, this is not the case. This is due to the fact that, in contrast to Baier and Bergstrand's (2006) linear expansion, in the asymmetric case the trade resistance variables are not functions of the simple averages but of the weighted ones (weights are θ^S and θ^N). This is unfortunate since it means that the RHS variables are not completely exogenous[23].

In any case, since θ^S and θ^N are almost invariant across time, distance and the dummy variables for border and language (accounting for the multilateral terms) are almost completely invariant as well, which means that their estimation by the fixed effects model is not ideal[24]. Including them in the estimation produces coefficients with strange signs and magnitudes and sometimes insignificant, but the results for foreign aid, our variable of interest, are similar[25]. Therefore, in the table below, distance and the dummy variables are excluded from the estimation.

[23] See B&B (2006) page 18 and their concluding remarks

[24] The fixed effects model produces the same coefficients and disturbances as an OLS estimation including dummies for each country-pair. These dummies would be highly collinear with distance and the dummy variables for border and language (accounting for the multilateral terms) given the near invariability of θ^S and θ^N.

[25] When we include all variables, Foreign aid has coefficient 0.0115615 and p. value 0.0000. Distance, Border and Language have coefficients -1.072604, -14.6197and 2.2545124 (p. values of 0.00, 0.00, 0.1410) respectively.

Table 4: Main Estimation Procedure

Estimations Results - Equation (63)

	Pooled OLS	**Fixed Effects**
Foreign Aid	0.0117	0.0052
	p. value (0.0000)	p. value (0.0000)
Distance	-0.0001	.
	p. value (0.0000)	
Border	0.7963	.
	p. value (0.0000)	
Language	0.7142	.
	p. value (0.0000)	
Observations	115165	115165
R-squared	0.2032	
Joint signif. Of all regressors (p-value of F-statistic)	0.0000	0.0000
Fixed country-pair effects (p-value of F-statistic)		0.0000
Fixed time effects (p-value of F-statistic)	0.0000	0.0000

Notes:

1. All variables transformed as in equations (61) and (62). The dependent variable is the trade flow minus the logarithmic form of both countries' GDP.
2. Time dummies included.
3. Aid is proxied by its 5th lag.

The first question we address is how these results compare to the ones obtained using B&B's (2007) and Feenstra's (2002) estimation procedures. The reason is, since the issue of multilateral barriers was raised by AvW (2003), these two methodologies are the ones that consistently estimate the gravity equation without the shortcomings of a nonlinear estimation[26]. We first present B&B's (2007) results. In the first two columns of next table, only Northern exporters are included. However, the symmetry assumption assumed in their procedure implies that the whole dataset should be used. Therefore, the last two columns refer to the coefficients obtained when all Southern exporters are also included.

[26] However, comparative statics can only be easily computed using B&B's methodology.

Table 5: B&B Estimation Procedure

Estimations Results - B&B

	Pooled OLS (Northern Exporters)	**Fixed Effects (Northern Exporters)**	**Pooled OLS (Whole Sample)**	**Fixed Effects (Whole Sample)**
Foreign Aid	0.0102	0.0089	0.022555	0.0031896
	p. value (0.0000)	p. value (0.0000)	p. value (0.0000)	p. value (0.0000)
Distance	-0.0001		-0.0001473	
	p. value (0.0000)		p. value (0.0000)	
Border	1.3201		1.565564	
	p. value (0.0000)		p. value (0.0000)	
Language	0.9045		0.8254977	
	p. value (0.0000)		p. value (0.0000)	
Observations	115165	115165	269279	269279
R-squared	0.2214		0.2016	
Joint signif. Of all regressors (p-value of F-statistic)	0.0000	0.0000	0.0000	0.0000
Fixed time effects (p-value of F-statistic)	0.0000	0.0000	0.0000	0.0000

Notes:

1. As in equation (59), the dependent variable is trade flow minus the logarithmic form of both countries' GDP.

2.Although in B&B's methodology all exporters should be included, only exporters in the North are considered in the first two collomuns for comparison purposes. The third and fourth collumn present the results refering to the whole sample.

3. Time dummies included.

4. Aid is proxied by its 5th lag

Comparing to table 1, we first note that, including only Northern exporters, the results are similar except for the Border's coefficient. Using B&B's procedure almost doubles this coefficient. That is interesting since, although not in the scope of this paper, the "border effect" is an important topic in the current literature. On the other hand, including the whole sample in the estimations, B&B's procedure coefficients that differ substantially from our specification.

We now present estimations according to Feenstra's (2002) methodology, where the coefficients are estimated by OLS and a country dummy is included for each importer and for each exporter.

Table 6: Feenstra's methodology

Estimation Results - Feenstra

	Country Dummies
Foreign Aid	0.0063714 p. value (0.0000)
Distance	-0.0001526 p. value (0.0000)
Border	0.8224119 p. value (0.0000)
Language	0.8780952 p. value (0.0000)
Observations	115165
R-squared	0.3162
Joint signif. Of all regressors (p-value of F-statistic)	0.0000
Fixed time effects (p-value of F-statistic)	0.0000

Notes:

1. Variables are not transformed as in equations (61) and (62). Besides, a set of dummies is included for each exporter and another set for each importer.

2. Time dummies included.

Except for foreign aid, the results are not so different from ours. This seems like a sensible result. Feenstra's methodology is consistent under the assumption of monopolistic competition in all countries.

Before the sensitivity analysis is presented, an important question must be considered. Do aid's coefficients change over time? To address these questions, equation (59) is estimated for every 5-year period of our sample.[27] The results are presented in the next table.

[27] We thank Oliver Morrissey (University of Nottingham) for suggesting this procedure.

Table 7: Estimation Procedure – Different Time-Periods

Foreign Aid's Coefficients - Different Time Periods

	Coefficients	Observations
1966 - 1970	0.0169417 p. value (0.0000)	10451
1971-1975	0.0263641 p. value (0.0000)	15501
1976-1980	0.0280716 p. value (0.0000)	16427
1981-1985	0.0149253 p. value (0.0000)	16725
1986-1990	-0.0011347 p. value (0.360)	16333
1991-1995	0.0083883 p. value (0.0000)	19176
1996-2000	0.0055431 p. value (0.0000)	20552

Notes:

1. All variables transformed as in equations (61) and (62). The dependent variable is the trade flow minus the logarithmic form of both countries' GDP.
2. Time dummies included.
3. Aid is proxied by its 5th lag.

Note that the aid coefficients decreased in the last two decades. This is expected, for instance, given the decrease in colonial ties and the increase in competition. We now present some sensitivity analysis.

Sensitivity Analysis

We start our sensitivity analysis presenting the results of our main specification but aid is now in levels and transformed according to equation (62). Although the coefficient of foreign aid is obviously changed, its significance is not altered. All other variables present similar coefficients and significance.

Table 8: Main Specification - Aid in Levels

Estimation Results - Aid in Levels

	Pooled OLS	Fixed Effects
Foreign Aid	1.3200E-09	-1.9200E-10
	p. value (0.0000)	p. value (0.043)
Distance	-0.0001	
	p. value (0.0000)	
Border	0.7128	
	p. value (0.0000)	
Language	0.7408	
	p. value (0.0000)	
Observations	115165	115165
R-squared	0.2010	
Joint signif. Of all regressors (p-value of F-statistic)	0.0000	0.0000
Fixed country-pair effects (p-value of F-statistic)		0.0000
Fixed time effects (p-value of F-statistic)	0.0000	0.0000

Notes:

1. Variables are transformed as in equations (61) and (62), but aid is in levels.
3. Aid is proxied by its 5th lag.
4. Time dummies included.

We now consider how the coefficients change when we do not include the multilateral effects. Note in the next table the smaller coefficient of foreign aid when only Northern exporters are included (first column). We have more to say about this in the comparative statics section.

Table 9: Estimations Without the Multilateral Effects

Estimations Results - No multilateral Effects

	Pooled OLS (Northern Exporters)	**Pooled OLS (Whole Sample)**
Foreign Aid	0.0079	0.0191
	p. value (0.0000)	p. value (0.0000)
Distance	-0.0001	-0.0001
	p. value (0.0000)	p. value (0.0000)
Border	0.9152	1.2862
	p. value (0.0000)	p. value (0.0000)
Language	0.9385	0.8261
	p. value (0.0000)	p. value (0.0000)
Observations	115165	269279
R-squared	0.2215	0.1986
Joint signif. Of all regressors (p-value of F-statistic)	0.0000	0.0000
Fixed country-pair effects (p-value of F-statistic)		
Fixed time effects (p-value of F-statistic)	0.0000	0.0000

Notes:

1. The equation estimated is the same as equation (63) except that the independent variables are not transformed as in equations (61) and (62). That is, only the bilateral effects are being considered.

2. Time dummies included

3. Aid is proxied by its 5th lag

We finish this sensitivity analysis applying to our data 2 recent methodologies of considerable importance in the literature. In the first, suggested by Santos Silva and

Tenreyro (2006), the dependent variable is in levels and the independent variables are in logs. The Poisson pseudo-maximum-likelihood is used in the same set of variables as in our main specification. However, now all the missing values of trade are assumed zero. The foreign aid coefficient has again the expected sign and is significant. The results are in the next table.

Table 10: Santos Silva and Tenreyro (2006) Procedure

Estimations Results - Santos Silva

	Coefficients (Northern Exporters)	**Coefficients (Whole Sample)**
GDP - exporter	0.7006666	0.7628305
	p. value (0.0000)	p. value (0.0000)
GDP -importer	0.7700523	0.7991889
	p. value (0.0000)	p. value (0.0000)
Foreign aid	0.0063638	0.0099465
	p. value (0.0000)	p. value (0.0000)
Distance	-0.0000991	-0.0001073
	p. value (0.0000)	p. value (0.0000)
Border	0.7986253	0.8443121
	p. value (0.0000)	p. value (0.0000)
Language	0.6226901	0.6694062
	p. value (0.0000)	p. value (0.0000)
Observations	170646	626310
Joint signif. Of all regressors (p-value of F-statistic)	0.0000	0.0000

Notes:

1. Exports are in level. When trade is not reported, it is assumed zero.
2. Variables are not transformed as in equations (61) and (62).
3. Time dummies included

Finally, we adapt to our context the methodology suggested by Wagner (2003). His method relies on the assumption that unmeasured variables on average affect imports in the same way that they affect exports. Therefore, we adapt it to our case in the following way. For every pair of countries, first we run an OLS regression of the exports from the second member of the pair to the first and compute the residuals. These are used as an independent variable, proxying the unobserved effects, in the main regression, that is, of the exports of countries from the first member of the pair to the second. In addition, to be able to compare our results with Wagner's (2003), we transform our aid variable according to the method used in that paper. More specifically, to take into account the cases that aid is zero, his specification is as follows:

$$\beta_1 \ln\Big(\max\{ 1, \text{ foreign aid level}\} \Big) + \beta_2 \, \big(\text{No aid dummy}\big) \qquad (64)$$

Therefore, the effect of no aid is equal to β_2 while the effect of aid is given by β_1 times the logarithm of the foreign aid level. The results are presented in the following table.

Table 11: Wagner Estimation Results

Estimations Results - Wagner

	Coefficients (Northern Exporters)	Coefficients (Whole Sample)
ln(max{1, foreign aid})	0.00714	-0.00514
	p. value (0.0000)	p. value (0.046)
No foereign aid dummy	-0.03700	-0.52611
	p. value (0.0000)	p. value (0.0000)
Distance	-0.00013	-0.00015
	p. value (0.0000)	p. value (0.0000)
Border	0.9074902	1.156558
	p. value (0.0000)	p. value (0.0000)
Language	0.9538165	0.8138
	p. value (0.0000)	p. value (0.0000)
Import Residual	0.2576639	0.2798
	p. value (0.0000)	p. value (0.0000)
Observations	86104	178820
R-squared	0.3265	0.2830
Joint signif. Of all regressors (p-value of F-statistic)	0.0000	0.0000

Notes:

1. The import residual is obtained in the following way. First, a regression where trade flows, say, from country "a" to country "b", is obtained. The predicted error terms are the "Import residuals" and are included as an independent variable in the esti

2.Variables are not transformed as in equations (61) and (62).

3. Time dummies included

4. Both Aid variables are proxied by its 5th lag

Our results contrast with those obtained by Wagner (2003). Considering only the Northern exporters (first column), the sign of the aid first term is positive and the sign of the second is negative. In Wagner, both signs are positive. To investigate why, we change our estimations such as to include his choice of variables. Different from us, the author includes the logarithm of the product of both countries income divided by the world income, $\ln Y_i Y_j / Y^W$, in the right hand side, along with other variables such as both countries' per capita incomes, remoteness indexes and Mill's ratio[28] (see author for complete list of variables and methodology). When we include the income related variables in the right hand side, we get results similar to his. However, as B&B (2007) argue, this procedure introduces endogeneity in the estimation and since the strategy of local linearization was developed by B&B in part to avoid this problem, we prefer our methodology. However, in both cases, the effect of aid is significant, and that is the point we are aiming to argue in this sensitivity analysis.

5) Comparative Statics

One of the main advantages of adapting B&B's (2007) procedure to our case is that it enables us to perform comparative statics. That turns out to be very important since the results are striking. The changes in bilateral trade costs, broadly construed, caused by foreign aid increased the volume of exports from the donor to the recipient, as the positive coefficient indicates. However, it also affects the multilateral trade costs of all other country pairs, donors or non-donors. It turns out that such changes in the multilateral trade barriers cause a reduction on the volume of trade of non-donors and, since those constitute the majority of countries, the total volume of exports from the North is reduced. We start this section with the formal derivation of the comparative statics and finish presenting the results.

Methodology to Compute Comparative-Static Effects[29]

Recall that we propose the following functional forms for t_{ij}:

$$t_{ij} = aid^{\beta_1} dist_{ij}^{\beta_2} e^{\beta_3 border_{ij}} e^{\beta_4 lang_{ij}} \tag{65}$$

[28] The Mill's ratio is to control for the probability that trade between two countries is observed (Heckman procedure).
[29] Our approach follows B&B (2007) as closely as possible considering our asymmetric model.

Note that, since foreign aid often is equal to zero, in order to obtain the logarithmic form we must add a small value to it. To start, we can simplify the notation by rewriting the equation above as:

$$t_{ij} = aid^{\beta_1} dist_{ij}^{\beta_2} e^{\beta_3 border_{ij}} e^{\beta_4 lang_{ij}} = aid_{ij}^{\beta_i} A_{ij} \tag{66}$$

Given that, introducing (66) in (8), for i in the North, we have:

$$x_{ij} = \frac{y_i y_j}{y^W} \frac{\left(aid_{ij}^{\beta_i}\right)^{1-\sigma}}{\left(\Pi_i P_j\right)^{1-\sigma}} \tag{67}$$

On the other hand, if there were no foreign aid, the trade flow would be given by:

$$x_{ij}^* = \frac{y_i y_j}{y^W} \frac{\left(A_{ij}\right)^{1-\sigma}}{\left(\Pi_i^* P_j^*\right)^{1-\sigma}} \tag{68}$$

Where the notation follows B&B (2007). Given that, $\frac{x_{ij}}{x_{ij}^*} = \frac{\left(aid_{ij}^{\beta_i}\right)^{1-\sigma}\left(\Pi_i^* P_j^*\right)^{1-\sigma}}{\left(\Pi_i P_j\right)^{1-\sigma}}$ and

$$\ln x_{ij} - \ln x_{ij}^* = \left(1-\sigma\right)\ln aid_{ij}^{\beta_i} + \ln \Pi_i^{*1-\sigma} - \ln \Pi_i^{1-\sigma} + \ln P_j^{*1-\sigma} - \ln P_j^{1-\sigma} \tag{69}$$

Replacing (66) in our linear expansions [equations (38) and (40)], we have that:

$$\ln \Pi_i^{1-\sigma} = \sum_{\substack{j\in N \\ j\in S}} \theta_j \left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i} A_{ij}\right) - \frac{1}{2\sum_{i\in N}\theta_i} \sum_{i\in N}\sum_{\substack{j\in N \\ j\in S}} \theta_j \theta_i \left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i} A_{ij}\right)$$

and

$$\ln P_j^{1-\sigma} = \frac{1}{\sum_{i\in N}\theta_i}\left(\sum_{i\in N}\theta_i\left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i}A_{ij}\right) - \frac{1}{2}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_i\theta_j\left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i}A_{ij}\right)\right) \quad (70)$$

Besides, assuming no foreign aid:

$$\ln \Pi_i^{*1-\sigma} = \sum_{\substack{j\in N\\ j\in S}}\theta_j\left(1-\sigma\right)\ln\left(A_{ij}\right) - \frac{1}{2\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_j\theta_i\left(1-\sigma\right)\ln\left(A_{ij}\right) \quad (71)$$

$$\ln P_j^{*1-\sigma} = \frac{1}{\sum_{i\in N}\theta_i}\left(\sum_{i\in N}\theta_i\left(1-\sigma\right)\ln\left(A_{ij}\right) - \frac{1}{2}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_i\theta_j\left(1-\sigma\right)\ln\left(A_{ij}\right)\right) \quad (72)$$

Therefore:

$$\ln \Pi_i^{*1-\sigma} - \ln \Pi_i^{1-\sigma} = -\sum_{\substack{j\in N\\ j\in S}}\theta_j\left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i}\right) - \frac{1}{2\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_j\theta_i\left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i}\right) \quad (73)$$

$$P_j^{*1-\sigma} - P_j^{1-\sigma} = -\frac{1}{\sum_{i\in N}\theta_i}\sum_{i\in N}\theta_i\left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i}\right) + \frac{1}{2}\frac{1}{\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_i\theta_j\left(1-\sigma\right)\ln\left(aid_{ij}^{\beta_i}\right) \quad (74)$$

Finally:

$$\begin{aligned}\ln x_{ij} - \ln x_{ij}^{*} = {} & \left(1-\sigma\right)\ln aid_{ij}^{\beta_i} \\ & -\sum_{\substack{j\in N\\ j\in S}}\theta_j\left(1-\sigma\right)\ln aid_{ij}^{\beta_i} - \frac{1}{\sum_{i\in N}\theta_i}\sum_{i\in N}\theta_i\left(1-\sigma\right)\ln aid_{ij}^{\beta_i} \\ & + \frac{1}{\sum_{i\in N}\theta_i}\sum_{i\in N}\sum_{\substack{j\in N\\ j\in S}}\theta_j\theta_i\left(1-\sigma\right)\ln aid_{ij}^{\beta_i}\end{aligned} \quad (75)$$

Thus, as in B&B (2007), estimates of the comparative static effects do not require estimating $\Pi_i *^{1-\sigma}$ or $P_j *^{1-\sigma}$.[30]

The equation above is quite interesting. The first term is the bilateral effects while the other three account for the multilateral trade barriers. Since both shares are necessarily smaller than one, the last term is relatively smaller than the second and third. Therefore, since the coefficient of aid is positive, we expect the total effect of trade to be smaller than the bilateral effect.

Comparative Statics Results

The following tables present the simple and trade weighted percentage mean of the increase in Northern country exports caused by foreign aid. Note that those were calculated according to (75).

Starting with donors, we see a simple mean of 1.51% and trade weighted mean of 2.51% across the years (end of the second and third column). We can also see that this percentage is more or less constant.

[30] For a discussion on the advantages and limitations of using the Taylor first order approximation for comparative statics, see B&B (2007).

Table 12: Trade Weighted and Simple Means - Increase in Trade (Percentage)

Donors

Year	Simple Mean (%)	Weighted Mean (%)	obs
1962	1.82	3.15	154
1963	1.76	3.04	174
1964	1.55	3.08	203
1965	1.47	2.98	232
1966	1.57	2.98	226
1967	1.26	2.56	270
1968	1.16	2.37	262
1969	0.97	2.34	282
1970	0.92	2.08	308
1971	1.37	2.35	321
1972	1.42	2.52	342
1973	1.61	2.61	366
1974	1.71	2.55	406
1975	1.72	2.75	456
1976	1.71	2.54	469
1977	1.72	2.59	505
1978	1.78	2.61	548
1979	1.86	2.50	590
1980	1.85	2.48	644
1981	1.68	2.39	675
1982	1.54	2.37	711
1983	1.40	2.45	724
1984	1.30	2.29	727
1985	1.16	2.25	751
1986	1.48	2.28	789
1987	1.60	2.60	827
1988	1.52	2.39	872
1989	1.42	2.33	912
1990	1.50	2.41	1037
1991	1.47	2.46	1118
1992	1.58	2.62	1166
1993	1.45	2.59	1158
1994	1.42	2.57	1192
1995	1.42	2.46	1265
1996	1.51	2.57	1274
1997	1.46	2.27	1241
1998	1.43	2.24	1246
1999	1.15	2.01	1253
2000	1.02	1.96	1250
Total	**1.46**	**2.37**	**26946**

On the other hand, the effects on the non-donor countries are quite different. Although they do not have the bilateral effect (aid is substituted by 0.0001), the multilateral effects are mostly negative. That can be seen in the next table. The average trade flow reduction by year is around 11%.

Table 13: Trade Weighted and Simple Means - Increase in Trade (Percentage)
Non-donors

Year	Simple Mean (%)	Weighted Mean (%)	obs
1962	-12.40	-12.27	6570
1963	-12.28	-12.23	6550
1964	-12.20	-12.16	6521
1965	-12.08	-12.06	6492
1966	-12.04	-12.10	6498
1967	-11.95	-12.06	6454
1968	-11.96	-12.04	6462
1969	-11.91	-12.00	6442
1970	-11.88	-11.95	6416
1971	-11.71	-11.99	6403
1972	-11.62	-11.83	6382
1973	-11.54	-11.87	6358
1974	-11.48	-11.87	6318
1975	-11.48	-11.75	6268
1976	-11.47	-11.80	6255
1977	-11.49	-11.80	6219
1978	-11.53	-11.73	6176
1979	-11.49	-11.87	6134
1980	-11.45	-11.88	6080
1981	-11.53	-11.79	6049
1982	-11.55	-11.86	6013
1983	-11.59	-11.90	6000
1984	-11.58	-11.99	5997
1985	-11.71	-12.08	5973
1986	-11.69	-12.06	5935
1987	-11.67	-12.02	5897
1988	-11.70	-12.03	5852
1989	-11.76	-12.04	5812
1990	-11.78	-12.12	5687
1991	-11.71	-12.36	5606
1992	-11.66	-12.34	5558
1993	-11.59	-12.27	5566
1994	-11.60	-12.04	5532
1995	-11.49	-12.15	5459
1996	-11.40	-12.20	5450
1997	-11.28	-12.19	5483
1998	-11.32	-12.10	5478
1999	-11.44	-12.23	5471
2000	-11.44	-12.21	5474
Total	**-11.69**	**-12.09**	**235290**

Comparing the two previous tables, we can see why the overall exports from the North were reduced. That can be seen in the next table.

Table 14: Trade Weighted and Simple Means - Increase in Trade (Percentage)
Total

Year	Simple Mean (%)	Weighted Mean (%)	obs
1962	-12.08	-10.50	6724
1963	-11.92	-10.57	6724
1964	-11.78	-10.45	6724
1965	-11.61	-10.42	6724
1966	-11.59	-10.49	6724
1967	-11.42	-10.50	6724
1968	-11.45	-10.60	6724
1969	-11.37	-10.75	6724
1970	-11.29	-10.74	6724
1971	-11.09	-10.73	6724
1972	-10.96	-10.80	6724
1973	-10.82	-10.79	6724
1974	-10.68	-10.61	6724
1975	-10.58	-10.27	6724
1976	-10.55	-10.44	6724
1977	-10.50	-10.48	6724
1978	-10.45	-10.28	6724
1979	-10.32	-10.51	6724
1980	-10.18	-10.30	6724
1981	-10.20	-10.11	6724
1982	-10.17	-10.18	6724
1983	-10.19	-10.25	6724
1984	-10.19	-10.50	6724
1985	-10.27	-10.66	6724
1986	-10.14	-10.75	6724
1987	-10.04	-10.69	6724
1988	-9.99	-10.63	6724
1989	-9.97	-10.60	6724
1990	-9.73	-10.56	6724
1991	-9.52	-10.30	6724
1992	-9.36	-10.06	6724
1993	-9.35	-9.64	6724
1994	-9.29	-9.75	6724
1995	-9.06	-9.57	6724
1996	-8.95	-9.49	6724
1997	-8.93	-9.52	6724
1998	-8.96	-9.54	6724
1999	-9.10	-9.66	6724
2000	-9.12	-9.64	6724
Total	**-10.34**	**-10.03**	**262236**

These results exemplify the importance of adopting a methodology that takes into account multilateral effects. While our bilateral effects match the literature, our comparative static results are quite unexpected.

6. Conclusion

The purpose of this paper is to study the impact of foreign aid on trade using the Gravity Equation. The choice of this empirical tool is very convenient since, after recent theoretical developments, it allows not only to estimate the bilateral effects of foreign aid on trade but also to compute general equilibrium comparative statics given that multilateral effects are properly tacked in the modeling.

However, the traditional way that the gravity equation is estimated does not take into account the fact that aid is usually donated by developed countries to less developed ones and these tow groups of countries have different patterns of trade. Given that, we propose a more appropriate empirical model that takes these factors into account.

More specifically, we use insights from the foreign aid literature on the channel by which aid affects trade, that is, the "bilateral economical and political link" channel, and include it in the "trade resistance barriers" concept developed by the gravity equation literature.

The AvW (2003) model, which takes into account both bilateral and multilateral trade resistance barriers, is then extended to include the North and the South. Countries in the South are assumed to produce homogenous goods and countries in the North heterogeneous ones (monopolistic competition), assumptions that result in a gravity equation more adequate to our purposes. We also apply B&B (2006) linearization technique to increase the clarity and efficiency of our estimations.

Foreign aid has a positive significant impact on exports from the donor to the recipient in the estimation framework proposed. Furthermore, this significance survives a series of sensitivity analyses proposed, including the use of the estimation procedures discussed by Feenstra (2002) and Santos Silva and Tenreyro (2006).

The magnitude of the impact is not as striking as the comparative static results. Despite its positive bilateral effects, aid affects prices such as to reduce the volume of trade of non-donor Northern exporters. Since most Northern countries are non-donors, the total volume of exports from the North actually decreases.

Appendix 1: Expanding A&W (2003) Without the Symmetry Assumption

Consider the original A&W (2003) model but without the assumption that $t_{ij} = t_{ji}$. The multilateral resistance to trade factors are:

$$P_j = \left(\sum_{i=1}^{N} \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \theta_i \right)^{\frac{1}{1-\sigma}}$$

$$\Pi_i = \left(\sum_{j=1}^{N} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \theta_j \right)^{\frac{1}{1-\sigma}}$$

Where N is the total number of countries. Note that the model is still symmetric in the sense that every country trades in a monopolistic competition framework, importing and exporting to and from every country. Following B&B (2006), we expand the equations above using a "symmetric world" (page 14) as the center. Denoting the variables at the center by P, Π, t, θ, note that:

$$P^{1-\sigma} = Nt^{1-\sigma}\Pi^{\sigma-1}\theta \tag{1}$$

we rewrite the first equation as

$$e^{\ln P_j^{1-\sigma}} = \sum_{i=1}^{N} e^{(1-\sigma)\ln t_{ij}} e^{(\sigma-1)\ln \Pi_i} e^{\ln \theta_i}$$

The log-linear Taylor expansion is then given by:

$$P^{1-\sigma} + (1-\sigma)P^{1-\sigma}\left(\ln P_j - \ln P\right) = Nt^{1-\sigma}\Pi^{\sigma-1}\theta +$$
$$+ t^{1-\sigma}\Pi^{\sigma-1}\theta\sum_{i=1}^{N}\left[(1-\sigma)\left(\ln t_{ij} - \ln t\right) + (\sigma-1)\left(\ln \Pi_i - \ln \Pi\right) + \left(\ln \theta_i - \ln \theta\right)\right]$$

Subtracting $P^{1-\sigma}$ from both sides and then dividing by $P^{1-\sigma}$, we have:

$$\left(1-\sigma\right)\left(\ln P_j - \ln P\right) = \frac{1}{N}\sum_{i=1}^{N}\left[\left(1-\sigma\right)\left(\ln t_{ij} - \ln t\right) + \left(\sigma - 1\right)\left(\ln \Pi_i - \ln \Pi\right) + \left(\ln \theta_i - \ln \theta\right)\right]$$

Using the logarithmic on both sides of (1) and replacing in the equation above, we have:

$$\ln P_j^{(1-\sigma)} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(1-\sigma\right)\left(\ln t_{ij}\right) + \left(\sigma - 1\right)\left(\ln \Pi_i\right) + \left(\ln \theta_i\right)\right] + \ln N \quad (2)$$

Similarly:

$$\ln \Pi_i^{(1-\sigma)} = \frac{1}{N}\sum_{j=1}^{N}\left[\left(1-\sigma\right)\left(\ln t_{ij}\right) + \left(\sigma - 1\right)\left(\ln P_j\right) + \left(\ln \theta_j\right)\right] + \ln N \quad (3)$$

Summing (2) across *j* and (3) across *i*, we have:

$$\sum_{j=1}^{N} \ln P_j^{(1-\sigma)} = \frac{1}{N}\sum_{j=1}^{N}\sum_{i=1}^{N}\left(1-\sigma\right)\left(\ln t_{ij}\right) + \sum_{i=1}^{N}\left(\sigma - 1\right)\left(\ln \Pi_i\right) + \sum_{i=1}^{N}\left(\ln \theta_i\right) + N \ln N \quad (4)$$

$$\sum_{i=1}^{N} \ln \Pi_i^{(1-\sigma)} = \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N}\left(1-\sigma\right)\left(\ln t_{ij}\right) + \sum_{j=1}^{N}\left(\sigma - 1\right)\left(\ln P_j\right) + \sum_{j=1}^{N}\left(\ln \theta_j\right) + N \ln N \quad (5)$$

These equations are identical. That is expected. Note that, as the system of equations (10) and (11) in A&W (2003) has infinite solutions (with or without the assumption that $t_{ij} = t_{ji}$), so does its expansion. Again, we need a convenient price normalization[31]. For any given equilibrium and any given λ, if we multiply every price p_i by λ, we have the same real equilibrium (real bundles), with a different price normalization, where each P_j is multiplied by λ and each Π_i is multiplied by 1/ λ (See footnote 12 in A&W, 2003). Given that, for any given equilibrium, consider a price re-normalization such as the product of P_j equals the product of Π_i. To prove that this is possible, we need to find a λ such as

[31] AvW's convenient one was $P_i = P_j$, which is not implied by the assumption that $t_{ij} = t_{ji}$.

$\prod_{j=1}^{N} \widetilde{P}_j = \prod_{i=1}^{N} \widetilde{\Pi}_i$, where $\widetilde{P}_j = \lambda P_j$ and $\widetilde{\Pi}_j = \Pi_j / \lambda$ are the multilateral resistance factors after the price re-normalization. That is:

$$\prod_{j=1}^{N} \left(\lambda P_j\right) = \prod_{i=1}^{N} \left(\frac{\Pi_i}{\lambda}\right).$$

Solving for λ we have:

$$\lambda = \left(\frac{\prod_{i=1}^{N} \Pi_i}{\prod_{j=1}^{N} P_j} \right)^{\frac{1}{2N}}.$$

Therefore, given any equilibrium, we can always re-normalize prices to obtain the desired result. In this case:

$$\sum_{j=1}^{N} \ln P_j^{(1-\sigma)} = \sum_{i=1}^{N} \ln \Pi_i^{(1-\sigma)}$$

This implies, using (4) and (5):

$$\sum_{j=1}^{N} \ln P_j^{(1-\sigma)} = \sum_{i=1}^{N} \ln \Pi_i^{(1-\sigma)} = \frac{1}{2N} \sum_{i=1}^{N} \sum_{j=1}^{N} (1-\sigma)\left(\ln t_{ij}\right) + \frac{1}{2} \sum_{i=1}^{N} \left(\ln \theta_i\right) + \frac{1}{2} N \ln N$$

Substituting back:

$$\ln P_j^{(1-\sigma)} = \frac{1}{N} \sum_{i=1}^{N} (1-\sigma)\left(\ln t_{ij}\right) - \frac{1}{2N^2} \sum_{i=1}^{N} \sum_{j=1}^{N} (1-\sigma)\left(\ln t_{ij}\right) + \frac{1}{2}\left[\frac{1}{N} \sum_{i=1}^{N} \ln \theta_i + \ln N \right]$$

$$\ln \Pi_i^{(1-\sigma)} = \frac{1}{N}\sum_{j=1}^{N}(1-\sigma)(\ln t_{ij}) - \frac{1}{2N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}(1-\sigma)(\ln t_{ij}) + \frac{1}{2}\left[\frac{1}{N}\sum_{j=1}^{N}\ln\theta_j + \ln N\right]$$

If, for every country i and j, $t_{ij} = t_{ji}$, then the two expressions above are identical and we are back to the B&B case[32]. If that is not the case, the equations above may be different since $\frac{1}{N}\sum_{i=1}^{N}(1-\sigma)(\ln t_{ij})$ may not be equal to $\frac{1}{N}\sum_{j=1}^{N}(1-\sigma)(\ln t_{ij})$.

[32] Note that imposing $P_j = \Pi_j$ implies $\sum_{j=1}^{N}\ln P_j^{(1-\sigma)} = \sum_{i=1}^{N}\ln \Pi_i^{(1-\sigma)}$, so the price normalization proposed by AvW (2003) implies the price normalization proposed here. However, ours do not require symmetry.

Appendix 2: The Effect of Price Normalizations on the Price Indexes in the Current Model

Note that the demand equations in our model can be expressed as:

$$p_i t_{ij} c_{ij} = \alpha \left(\frac{p_i t_{ij}}{P_j} \right)^{1-\sigma} y_j \text{ for } i \text{ in the North} \tag{1}$$

$$p_i t_{ij} c_{ij} = (1-\alpha) y_j \text{ for } i \text{ in the South} \tag{2}$$

The Market clearing conditions can be restated as:

$$y_i = \sum_{\substack{j \in N \\ j \in S}} p_i c_{ij} t_{ij}, \quad i \in N \ (3)$$

$$y_i = \sum_{j \in I} p_i c_{ij} t_{ij}, \quad i \in S \ (4)$$

Besides, for i in the North and j in the North or South:

$$P_j = \left[\sum_{i \in N} \left(p_i t_{ij} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{5}$$

$$\Pi_i = \left[\sum_{j \in N \, or \, S} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \theta_j \right]^{\frac{1}{1-\sigma}} \tag{6}$$

Equations (1) to (5) determine the equilibrium. Consider now multiplying every p_i by some constant λ. By equations (3) and (4), we see that every nominal income is multiplied by λ. Besides, by equation (5), it is clear that every P_j is multiplied by λ as well. Those two facts together imply that equations (1) and (2) are unchanged. Therefore, as expected, the real bundles do not change.

The interesting result is that, in the re-normalized equilibrium, every P_j is multiplied by λ and every Π_i is divided by λ, as can be seen in equations (5) and (6). This is similar to what happens in AvW's (2003) model but, in the current case, Π_i is only defined for Northern countries.

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