GATT/WTO Membership Does Promote International Trade After All – Some New Empirical Evidence

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Abstract

The declared objective of the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO) is to encourage free trade between member states. Nonetheless, an exhaustive study of bilateral merchandise trade based on a gravity model and on a large panel data set led Rose (2004) to conclude that there is no compelling empirical evidence to show that GATT/WTO membership actually encourages international trade. This unanticipated finding generated a great deal of attention in the literature and several scholars put forward various explanations for it. In this paper we go back to the basics and set up a new international trade data set which, unlike Rose's, allows us to study the extensive margin of trade and to model exports and imports separately. First we systematically uncover the nature of this new data set and show that bilateral trade, despite being often unbalanced, tends to be reciprocal and persistent, and that the extensive margin is indeed vital in modeling it. We then, using a gravity framework, show how to obtain puzzling negative results and so explain the previous negative findings. Finally, using the new data set properly and appropriate procedures we show that GATT/WTO membership does unambiguously encourage international trade. Hence, the most obvious reason for Rose's negative finding is the lack of zero bilateral trade observations in his data set.

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1 Introduction

A quiet revolution has been going on in economics for a couple of years. A substantial part of it has been data driven, thanks to the new data sets which are becoming larger, richer, more informative and more reliable by the day. This phenomenon, paired up with the latest econometric and modeling tools, is forcing us to revisit many problems and questions that most of us thought were answered some time ago in a more or less satisfactory way. Frequently old wisdoms are falling and new exciting questions are arising.

International trade modeling cannot escape this trend. In principle, there are several possible ways to formalize trade behavior. One option is partial equilibrium modeling if one is interested in the effects of policy for a specific sector. Another is provided by computable general equilibrium models if interest is more economy wide and focus is on the relationship between production, consumption, goods and production factors. Nevertheless, since the pioneering studies of Tinbergen (1962) and Pöyhönen (1963) in empirical studies the gravity model has been the workhorse in this field. Its popularity is partly due to its empirical success in capturing the impact of trade liberalization and in assessing the effect of geographic regions and international agreements on trade.

Probably the best known example for these agreements are the General Agreement on Tariffs and Trade (GATT), which was first signed by 23 countries in 1947, and its successor the World Trade Organization (WTO), which was established in 1995 and currently has 153 member countries. Their declared objective is to encourage free trade between member states by regulating and reducing tariff barriers, quantitative restrictions and subsidies on traded goods and by providing a common mechanism for resolving trade disputes. Even so, in his recent seminal paper Rose (2004) argued that in spite of wishful thinking, conventional wisdom and casual empiricism, there is no compelling empirical evidence to support the wide spread claim that GATT/WTO membership has actually encouraged international trade. Although he based this conclusion on dozens of variants of a standard gravity model of bilateral merchandise trade estimated from a large panel data set covering 52 years and 175 countries, it is still hard to believe that GATT/WTO membership indeed systematically fails to boost bilateral trade because time after time existing and acceding countries alike are willing to cover the increasing costs of accession in the hope that it will promote trade between them (Felbemayr and Kohler, 2007).

Unsurprisingly, Rose (2004) has attracted many critiques which were concerned, among others, with pooling developed and developing countries, the classification of member and non-member countries, the sample period, the neglect of the extensive margin of trade, the selection of the dependent variable, and the specification and estimation of the econometric model. Although we agree with most of these assessments, in this paper we restrict ourselves to briefly reviewing them because we believe that, in spite of all the shortcomings brought up in these critiques, the positive impact of GATT/WTO on trade should reveal itself quite straightforwardly. Hence, we go back to the basics and set up a new, updated international trade data set. It has two major advantages over Rose's data set: it contains zero trade flows as well and allows us to study exports and imports separately. The coverage of our sample is slightly bigger than that of Rose's (180 countries), but its range is a bit shorter (46 years) so that the measurements be as homogenous, reliable and comparable as possible.

Our aim is twofold. First we systematically uncover the nature of this new data set and point at the most important stylized facts that characterize it from a modeling perspective. In particular, we show that bilateral trade, despite being often unbalanced, tends to be reciprocal and persistent, and that the extensive margin of trade must not be disregarded. Then we estimate

ordinary least squares (OLS), logit and Tobit gravity regressions. The OLS results computed solely from the strictly positive export and import flows are puzzling because GATT/WTO membership appears to have a negative impact on international trade. However, the OLS, logit and Tobit results obtained from all available zero and positive trade observations clearly indicate that GATT/WTO membership encourages international trade, both among member countries and with non-member countries. Although our sample and specification differ from Rose's, this contradiction between the results based on the positive flows and on all flows suggests that Rose's negative finding is most likely due to the lack of zero bilateral trade flows in his data set.

The rest of this paper proceeds as follows. Rose's benchmark study and some of the most relevant follow up studies are reviewed in Sections 2 and 3, respectively. The new data set is described in Section 4 and the stylized facts are discussed in Section 5. The gravity equation estimation results are reported in Section 6. Finally, this paper is wrapped up by the concluding remarks in Section 7.

2 Benchmark Study: Rose (2004)

In order to assess the effect of GATT/WTO membership on bilateral trade, Rose (2004) used a standard gravity model augmented by a number of conditioning variables related to culture, geography, history, and international trade agreements. The exact specification of the model was:

$$\begin{aligned}\ln ART_{ijt} = {} & \beta_0 + \beta_1 \ln(RGDP_{it} \times RGDP_{jt}) + \beta_2 \ln\left(\frac{RGDP_{it}}{POP_{it}} \times \frac{RGDP_{jt}}{POP_{jt}}\right) + \beta_3 \ln DIST_{ij} \\ & + \beta_4 \ln(LAND_i \times LAND_j) + \beta_5 CLANG_{ij} + \beta_6 CBORD_{ij} + \beta_7 NLLOCK_{ij} \\ & + \beta_8 NISLAND_{ij} + \beta_9 EVCOL_{ij} + \beta_{10} COMCOL_{ij} + \beta_{11} ISCOL_{ijt} + \beta_{12} CNAT_{ij} \\ & + \beta_{13} MUNI_{ijt} + \beta_{14} RTA_{ijt} + \gamma_1 ONEIN_{ijt} + \gamma_2 BOTHIN_{ijt} + \gamma_3 GSP_{ijt} + \sum \varphi_t YD_t + \varepsilon_{ijt}\end{aligned} \quad (1)$$

where ln denotes the natural logarithm and the variables are defined as follows:

ART_{ijt} : Average real bilateral trade between countries *i* and *j* in year *t*;
$RGDP_{it}$, $RGDP_{jt}$: Real GDPs of countries *i* and *j*, respectively, in year *t*;
POP_{it}, POP_{jt} : Populations of countries *i* and *j*, respectively, in year *t*;
$DIST_{ij}$: Great circle distance between countries *i* and *j*;
$LAND_i$, $LAND_j$: Land areas of countries *i* and *j*, respectively;
$CLANG_{ij}$: Dummy variable for common language (1 = *i* and j share a common language);
$CBORD_{ij}$: Dummy variable for common land border (1 = *i* and *j* are adjacent);
$NLLOCK_{ij}$: Number of landlocked countries in the *ij* country pair;
$NISLAND_{ij}$: Number of island countries in the *ij* country pair;
$EVCOL_{ij}$: Dummy variable for ever colonized (1 = *i* ever colonized *j* or vice versa);
$COMCOL_{ij}$: Dummy variable for common colonizer (1 = *i* and *j* were ever colonized by the same coloniser after 1945);
$ISCOL_{ijt}$: Dummy variable for colonizing (1 = *i* is the colonizer of *j* in year *t* or vice versa);
$CNAT_{ij}$: Dummy variable for common nation (1 = *i* and *j* remained part of the same nation during the sample periods);
$MUNI_{ijt}$: Dummy variable for monetary union (1 = *i* and *j* are in a real or de facto monetary union in year *t*);

RTA_{ijt} : Dummy variable for regional trade agreement (1 = *i* and *j* belong to the same regional trade agreement in year *t*);
$ONEIN_{ijt}$: Dummy variable for one country in GATT/WTO (1 = either *i* or *j* is a GATT/WTO member in year *t*);
$BOTHIN_{ijt}$: Dummy variable for both countries in GATT/WTO (1 = both *i* and *j* are GATT/WTO members in year *t*);
GSP_{ijt} : Dummy variable for Generalised System of Preferences (1 = *i* is a GSP beneficiary of *j* or vice versa in year *t*);
YD_t : Year dummy variable (1 = in year *t*).

As regards the interpretation of the coefficients, $\beta_1,\ldots, \beta_4$ are elasticities measuring the percentage change in average real bilateral trade in response to a given (small) percentage increase in the corresponding explanatory variables. In particular, due to the fact that both real GDP and real GDP per capita are used as explanatory variables, $\beta_1+\beta_2$ is the elasticity of ART_{ijt} with respect to $RGDP_i$ and also to $RGDP_j$, and $-\beta_2$ is the elasticity of ART_{ijt} with respect to POP_i and to POP_j. Moreover, β_3 and β_4 are the elasticities of ART_{ijt} with respect to $DIST_{ij}$, and to $LAND_i$ and $LAND_j$, respectively.

On the other hand, $\beta_5,\ldots, \beta_{14}$ and γ_1, γ_2, γ_3 are semi-elasticities, they measure the percentage change in average real bilateral trade for a one unit increase in the corresponding explanatory variables. For example, assuming that GATT/WTO membership has a positive effect on trade, the coefficients of the *ONEIN* extra-bloc dummy and the *BOTHIN* intra-bloc dummy variables show that, ceteris paribus, how much higher average real bilateral trade is between a GATT/WTO member and a non-member country, and between two GATT/WTO countries, respectively, than between two non-member countries. Given this interpretation, one would expect both coefficients to be positive and γ_1 to be smaller than γ_2. On the other hand, these dummy variables can be interpreted as representing the 'trade diversion' and 'trade creation' effects of GATT/WTO membership, implying $\gamma_1 < 0$ and $\gamma_2 > 0$. Yet, even in this case γ_1 can still be positive due to the externalities of GATT/WTO on non-member countries.

As for the signs of the other coefficients, ceteris paribus, we can expect richer countries, countries that share a language, common land border, or colonial history, countries that belong to the same trading group, monetary union, or have some special bilateral agreement to trade more with each other; while countries that are far apart from each other, or geographically larger are likely to trade less. Whether being landlocked or an island nation encourages trade or not seems to be ambiguous.

Rose (2004) estimated this model using a two-dimensional (country-pair and time) unbalanced panel data set for 175 countries over the 1948-1999 sample period. The data were collected from various sources.[1] Most importantly, average real bilateral trade (*ART*) between any given pair of countries was calculated by taking the arithmetic mean of merchandise exports (f.o.b., free on board) and imports (c.i.f., cost, insurance and freight) in both directions, i.e. of potentially four different measures. The nominal data on exports and imports in US dollars were taken from the IMF's *Direction of Trade Statistics* and were deflated by the US CPI for all urban consumers (1982-84 = 100). Population (*POP*) and real GDP (*RGDP*) data came from three sources: the *Penn World Table*, the World Bank's *World Development Indicators*, and the IMF's *International Financial Statistics*. Data on GATT/WTO membership (*ONEIN*, *BOTHIN*) were obtained from the WTO's web site, and on the Generalised System of Preferences (*GSP*) from the UN's

[1] The exact data sources can be found in Rose (2004, p. 101).

Operation and Effects of the Generalised System of Preferences booklets (published in 1974, 1979, and 1984).

Rose's 'default' OLS results are shown in the second column of *Table* 1.

Table 1: Rose's (2004) benchmark results

Dependent Variable: ln ART_{ijt}	*Coefficient (standard error)*	
	Default[b]	*Country fixed effects*[c]
$ONEIN_{ijt}$	-0.06 (0.05)	0.05 (0.04)
$BOTHIN_{ijt}$	-0.04 (0.05)	**0.15** (0.05)
$\ln (RGDP_{it} \times RGDP_{jt})$	**0.92** (0.01)	**0.16** (0.05)
$\ln (RGDP_{it} / POP_{it} \times RGDP_{jt} / POP_{jt})$	**0.32** (0.01)	**0.54** (0.05)
$\ln DIST_{ij}$	**-1.12** (0.02)	**-1.31** (0.02)
$\ln (LAND_i \times LAND_j)$	**-0.10** (0.01)	**0.38** (0.03)
$CLANG_{ij}$	**0.31** (0.04)	**0.27** (0.04)
$CBORD_{ij}$	**0.53** (0.11)	**0.28** (0.11)
$NLLOCK_{ij}$	**-0.27** (0.03)	**-1.54** (0.32)
$NISLAND_{ij}$	0.04 (0.04)	**-0.87** (0.19)
$EVCOL_{ij}$	**1.16** (0.12)	**1.27** (0.11)
$COMCOL_{ij}$	**0.58** (0.07)	**0.60** (0.06)
$ISCOL_{ijt}$	**1.08** (0.23)	**0.72** (0.26)
$CNAT_{ij}$	-0.02 (1.08)	0.31 (0.58)
$MUNI_{ijt}$	**1.12** (0.12)	**1.19** (0.12)
RTA_{ijt}	**1.20** (0.11)	**0.94** (0.13)
GSP_{ijt}	**0.86** (0.03)	**0.70** (0.03)
R^2	0.65	0.70

Note: a) The sample period is from 1948 through 1999, the number of countries is 175, and the number of observations is 234,597.
b) Rose (2004, p. 104), Table 1, column "Default".
c) Rose (2004, p. 104), Table 1, column "With country effects".
d) Both specifications also include period fixed effects, but they are not reported in this table. Slope estimates in bold are significant at the five percent level. The numbers in the parentheses are Huber-White heteroscedasticity consistent standard errors robust to clustering by country-pairs.

Overall, the results seem to be statistically satisfactory, the model explains close to 2/3 of the total variation in bilateral trade, and the significant coefficients have the logical signs. The elasticity of average real bilateral trade is 1.24 for real GDP, -0.32 for population, -1.12 for

distance, and -0.10 for land areas, respectively.[2] Being an island nation or part of the same nation appears to be irrelevant in terms of bilateral trade. Most importantly, however, the GATT/WTO membership dummy variables are insignificant.[3]

In order to see how robust this crucial piece of result is, Rose experimented with alternative specifications, estimation methods, subsets of countries, and sample periods, and concluded that the more than eighty regressions he ran failed to lend support to the hypothesis that GATT/WTO membership systematically encourages trade.

In the third column of *Table* 1 we report only one of these regressions based on model (1) augmented with country specific fixed effects.[4] Compared to the 'default' results, the qualitative effect of these fixed effects is twofold. First, the originally insignificant slope estimate of the *NISLAND* independent variable became significantly negative and the originally significantly negative slope estimate of $\ln(LAND_i \times LAND_j)$ is now significantly positive. Second, and more importantly, the slope estimate of *BOTHIN* too became significantly positive. It suggests that, ceteris paribus, bilateral trade between two GATT/WTO members is expected to be about 16% more than between non members.[5] Although Rose (2004, p. 104) light-heartedly dismissed this finding on the ground that the estimated effect of GATT/WTO membership on trade is small compared to other effects, it still raises doubts about Rose's overall conclusion.

3 Follow up Studies

Since its publication, Rose (2004) has attracted much positive attention and inspired a new field of scholarly research that focuses on the impact of trade treaties and organizations on international trade. At the same time, however, its outright rejection of a positive link between GATT/WTO membership and bilateral trade has also attracted many critiques. A number of potential reasons behind this seemingly implausible negative result have been raised in the

[2] The elasticity for real GDP is the sum of the coefficients for GDP (0.92) and GDP per capita (0.32). Since this sum is larger than one, ceteris paribus, any increase in GDP per capita raises trade more than proportionately (Rose, 2004, p. 103, footnote #15).

[3] Rose (2004) did not correct the estimated standard errors for the fact that his sample size is relatively large compared to the population size. Nevertheless, the finite population correction factor is about 0.84 (the population size is (52×175×174 / 2) = 791,700 and the square root of $(1 - n / N)$ is about 0.84), not small enough to turn *ONEIN* or *BOTHIN* significant.

[4] At one stage Rose (2004, p. 100) mentions that "unless otherwise noted, fixed and random effects are always country-pair specific", but he is actually using country specific fixed effects since a set of country-pair dummy variables would be perfectly multicollinear with all those independent variables which change in the *ij* dimension but not in time, like for example $DIST_{ij}$. In general, separate local and target country effects are better econometrically (Mátyás, 1997, 1998) and are parsimonious since it takes more country-pair dummy variables than country dummy variables to model bilateral trade among five or more countries. However, they do not fit naturally into Rose's two-dimensional, i.e. country-pair and time, framework and their application tacitly assumes that the group of country specific variables that are not considered explicitly has a constant impact on a country's international trade; let it be export or import and irrespectively of the trading partner. As regards the choice between fixed and random effects, according to Egger (2000), both simple intuitive arguments and empirical evidence based on Hausman's χ^2 statistic suggest that in most applications these effects are better be treated as fixed.

[5] $\frac{ART_{ijt,BOTHIN=1}}{ART_{ijt,BOTHIN=0}} - 1 = e^{0.15} - 1 = 0.1618$.

literature, some of them related to the data set, while others to the specification and estimation of the gravity equation.[6] In this section we briefly consider the six most relevant of them.
First, although GATT/WTO was set up to promote world trade, in terms of trade policy the formal members had never been and are not a homogeneous group of countries, neither in comparison to each other nor to non-members. This is partly due to the fact that many countries aspiring for membership enjoyed preferential treatment, most favored nation status, or voluntarily reduced their own trade barriers before accession, while member countries were allowed fairly long transition periods for tariff reduction (usually 5 to 10 years). Moreover, prior to 1994 developing countries wishing to accede were not required to reduce their own trade barriers significantly; and many developing countries are net exporters of fuels and minerals which traditionally face relatively low tariffs in developed countries. Consequently, the impact of GATT/WTO membership is likely to have a greater impact on trade in case of developed than developing countries, but this impact might be blurred in a mixed sample of developed and developing countries.

This is one of the key arguments of Subramanian and Wei (2007). Similarly to Rose (2004), they relied on a gravity equation, but their specification differs from (1) in three respects. Namely, since the relevant trade theories focus on unidirectional trade rather than total trade, their dependent variable is imports by country *i* from country *j*, instead of the average of the four potential flows between them. Second, in order to proxy for 'multilateral trade resistance' in a panel context, they use time-varying importer and exporter fixed effects and drop the country-specific variables. Third, they 'decompose' the GATT/WTO membership, and redefine the *RTA*, *GSP* dummy variables to ensure that they are mutually exclusive.

Using an updated version of Rose's (2004) data set[7], containing five-yearly observations between 1950 and 2000 inclusively, Subramanian and Wei managed to show that GATT/WTO membership had a statistically significant and economically substantial positive effect on world trade, amounting to about 120 percent of additional world trade. This impact, however, is uneven: it is important for the imports of developed countries, for the trade in the non-protected sectors, and for the new members, but it is marginal for the imports of developing countries, for the trade in the protected sectors, and for the old members.

A related issue raised by Tomz et *al.* (2007) is that GATT/WTO agreements, rights and obligations have been applied not only to formal members but also to non-member participants, like colonies, newly independent states, and provisional members.[8] Using the same data and methods than Rose (2004) but classifying countries by actual participation rather than formal membership, Tomz et *al.* (2007) showed that GATT/WTO increased the trade of both formal members and non-member participants substantially. In particular, according to the benchmark specification, compared with countries outside the agreement, trade is about 31 percent higher when one of the two trading partners participates in GATT/WTO, and it is 72 percent higher when both trading partners participate.[9]

[6] See Piermartini and Teh (2005, pp. 47-52) for a brief summary. This review and the related articles make reference to several unpublished manuscripts, but whenever it is possible we rely on their final paper versions.
[7] The observations for the new dependent variable, imports, had been obtained directly from the IMF's *Direction of Trade Statistics*, while observations for variables not present in equation (1) were obtained from additional UN sources (TRAINS and COMTRADE data bases).
[8] According to Tomz et al. (2007, p. 2016), "Over half of the observations that Rose classified as involving no GATT members actually involved countries that were bound by the agreement."
[9] Strangely, however, non-member participation seems to have a larger positive impact on trade than formal membership.

Third, Anderson and van Wincoop (2003) argued that bilateral trade is affected not simply by the absolute trade barriers between the two countries, but by the relative trade barriers, i.e. by the barriers between them relative to the average trade barriers they face with all their trading partners. For this reason, equation (1) has to be augmented with some multilateral resistance terms which are functions of all bilateral trade barriers. In practice, these terms are often proxied with remoteness variables, though according to Anderson and van Wincoop, they are rather related to some unobservable implicit price indices of the trading partners. This reasoning, combined with unit income elasticity[10] and other simplifying assumptions, leads to the following specification:

$$\ln \frac{EXPORT_{ijt}}{GDP_{it} \times GDP_{jt}} = \beta_0 + \beta_1 \ln DIST_{ij} - \ln P_{it}^{1-\sigma} - \ln P_{jt}^{1-\sigma} + ... + \varepsilon_{ijt} \qquad (2a)$$

subject to

$$P_{jt}^{1-\sigma} = \sum_i \frac{P_{it}^{1-\sigma} GDP_{it}}{WGDP_t} e^{\alpha \ln DIST_{ij}}, \quad \forall j \qquad (2b)$$

where the new notations denote

P_{it}, P_{jt}: Implicit price indices of countries *i* and *j*, respectively, in year *t*;
$EXPORT_{ijt}$: Nominal exports of country *i* to country *j* in year *t*;
GDP_{it}, GDP_{jt}: Nominal GDPs of countries *i* and *j*, respectively, in year *t*;
$WGDP_t$: World nominal income (GDP) in year *t*;
and in equation (2a) … indicates other explanatory variables that are typically used in gravity models.

This model can be estimated with nonlinear least squares (NLS). Alternatively, it is possible to replace the multilateral resistance terms with time-varying country-specific dummy variables and apply OLS. Anderson and van Wincoop are in favor of NLS, because it uses information on the full structure of the model and hence is more efficient than OLS with fixed-effects.

Fourth, Rose (2004) tacitly assumed that all right-hand side variables in equation (1) are determined exogenously. If, however, some of them are determined at least partially by the trade flows, then the results suffer from endogeneity bias. One obvious candidate is the GDPs of the partner countries which, by definition, include the differences between total exports and total imports. This is not a major problem though because net exports are typically fairly small compared to GDP, and the shares of individual bilateral trade flows are even smaller (Baier and Bergstrand, 2007, p. 79). A potentially more serious endogeneity bias is due to the fact that GATT/WTO or RTA membership might be influenced by the bilateral trade flows.[11]

Magee (2003), for example, considered both welfare and political arguments about which countries are likely to enter into preferential trade agreements and used instrumental variables (IV) in a cross-section gravity model to adjust for endogeneity. Baier and Bergstrand (2007),

[10] According to Silva and Tenreyro (2006, p. 650), this assumption is at odds with the observation that smaller countries are often more open to international trade than larger countries.
[11] Trefler (1993) and Lee and Swagel (1997) focused on a similar endogeneity bias in estimating the effect of nontariff barriers on trade flows.

however, warned that some of these instruments are most likely correlated with the unobservable variables behind trade flows and rejected the IV method for addressing the endogeneity bias in cross-sectional gravity models. Instead, they advocated the use of level panel data with country-pair and country-and-time fixed effects or first-differenced panel data with country-and-time fixed effects. Based on five-yearly data[12] from 1960 to 2000 for 96 countries, the results of Baier and Bergstrand indicate that on average a free trade agreement increases the partner countries' trade by about 100% after 10 years.

The next issue is related to zero trade observations. The log-linear specification of equation (1) and similar gravity equations requires that all trade flow observations be positive. This is an important restriction because about half of all country pairs do not trade with each other at all, while many others do but relatively little so in the IMF's *Direction of Trade Statistics* and similar data banks their bilateral trade flows are recorded as zeros. Unfortunately, the 'genuine' and 'rounded' zeros cannot be told apart, and it is usually also impossible to distinguish between zero and missing trade flows.

A simple pragmatic solution to zero observations in general is to increase all trade flow measurements by a small amount, like for example in Harris et *al*. (2002).[13] Yet, Rose (2004) and several other empirical studies rather dropped zero trade observations and focused on those country pairs and time periods for which positive trade flows were recorded. Among others, Helpman et *al*. (2008) and Felbermayr and Kohler (2006) criticized this practice because by considering the intensive margin of trade, i.e. the growth of trade in existing relationships, but ignoring the extensive margin of trade, i.e. the change of the number of bilateral trade relationships, these studies produced biased estimates with dubious interpretations.

To avoid this bias, in the footstep of Heckman (1979), Helpman et *al*. (2008) proposed a simple two-equation model based on differentiated products and heterogeneous firms. Exports incur fixed and variable costs, and the profitability of exports might vary by destination. By jointly determining the set of trading partners and their trade volumes, this model can predict zero and positive trade flows alike. Moreover, the bilateral trade flows need not be symmetric and the importer specific effects may differ from the exporter specific effects. This model enables the decomposition of the impact on trade of various trade resistance terms into intensive and extensive margin components. An important feature of this approach is that although it assumes firm heterogeneity, it focuses on the marginal exporters whose characteristics are determined by the features of the destination countries and the bilateral trade costs. Consequently, there is no need for firm-level data to estimate the aggregate gravity equation.

Helpman et *al*. (2008) implemented three two-stage estimation procedures that make use of the information contained not only in the data of trading partners but that of non-trading countries too; a fully parameterized NLS method, a semi-parametric method, and a nonparametric method. In each case, the first stage constitutes the estimation of a Probit selection equation of the trading partners and subsequently the predicted probabilities of trading are used in the

[12] Nominal trade flows from the IMF's *Direction of Trade Statistics* and nominal GDP from the World Bank's *World Development Indicators* had been scaled by GDP deflators, while the data for most other variables were compiled from the CIA's *World Factbook*.

[13] Although in theory this data manipulation results in inconsistent estimators, if the constant is indeed small relative to the positive trade flows, then one would expect the asymptotic biases to be small. Still, Silva and Tenreyro (2006) advised against this procedure because according to their cross-sectional simulation study the performance of the OLS estimator for the log-linear version of a constant elasticity model where the dependent variable is the log of (y_i+1) is rather poor. It has to be mentioned though, that in these simulations the expected value of y_i was only 1.49, not much larger than the additive constant.

second stage estimation of a gravity equation with importing and exporting country fixed effects. The results based on the real exports[14] between 158 countries in 1986 indicate that the traditional estimates are biased and that most of the bias is due to the oversight of the extensive margin of trade.[15] Yet, the rapid growth of world trade from 1970 to 1997 was predominantly due to the growth on the intensive margin of trade.

Felbermayr and Kohler (2006) decomposed world trade growth to changes on the intensive margin and changes on the extensive margin, and the latter was further broken down to changes in the utilization of pre-existing trading relationships, called 'extensive margin proper', and to changes in the number of potential trading relationships due to the emergence of new countries and to the disappearance of old ones, called 'pseudo-extensive margin'. A simple descriptive analysis based on this decomposition revealed that between 1950 and 1997 about 40 percent of world trade growth occurred on the extensive margin, and that the 'extensive margin proper' was about as important as the intensive margin.[16]

Felbermayr and Kohler (2006) further highlighted the importance of the extensive margin by showing that while exporter and importer fixed effects alone are insufficient to solve Rose's GATT/WTO puzzle, a Probit gravity equation indicates that the probability to find an existing trade relationship is about 10 percentage points higher for two GATT/WTO member countries than for two non-members. A similar, though numerically smaller estimate resulted from the Tobit approach to a gravity model characterized by corner-solutions, meaning that in any given relationship bilateral trade is supposed to be equal to its full potential if it exceeds some threshold level, and zero otherwise.

The final potential problem is related to heteroscedasticity, which is almost inevitable present in gravity models because the trade flows between relatively small countries are likely to vary less than the trade flows between relatively large countries. Since heteroscedasticity itself does not bias or make the OLS estimators inconsistent but destroys their efficiency and makes inference difficult, OLS point estimates are often used along with heteroscedasticity-robust standard errors, like in Rose (2004), for example. However, as Silva and Tenreyro (2006, p. 644) pointed out, even if a multiplicative constant-elasticity (i.e. non-linearized) gravity equation is correctly specified, in the presence of heteroscedasticity the OLS estimators of the coefficients of its log-linear version can still be seriously biased. Namely, if the variance of the multiplicative error term in the original non-linearized gravity equation, say ω_{ijt}, depends on any of the independent variables, then the expected value of $\varepsilon_{ijt} = \ln \omega_{ijt}$ in equation (1) is likely to depend on that variable too, violating the condition for consistency of OLS.

For this reason, Silva and Tenreyro warned against log-linearized regressions in general. They also rejected estimating constant-elasticity gravity equations with NLS because NLS estimators can be very sensitive to heteroscedasticity. Instead, they suggested estimating these models with the Poisson pseudo-maximum likelihood (PPML) method, which is based on the

[14] The bilateral trade flows came from Feenstra et *al*. (1997) and one of its earlier versions, population and real GDP per capita were obtained from the *Penn World Tables 6.1* and the World Bank's *World Development Indicators*, and the observations for most of the other variables were extracted from the CIA's *World Factbook*.

[15] This conclusion is not specific to 1986, Helpman et *al*. (2008) obtained similar results when the gravity equation was augmented with year fixed effects and re-estimated for the 1980s.

[16] Felbermayr and Kohler (2006) used Rose's data, but only from 1950 to 1997 because during that period very few new countries came into existence so the results were not expected to be driven by the pseudo-extensive margin.

assumption that the conditional variance and the conditional mean of the dependent variable are proportional to each other.[17] The PPML estimator is consistent as long as the conditional mean of the dependent variable is correctly specified, even if the data is not Poisson or not even integer. Moreover, the PPML estimator offers a natural way to deal with zero trade flows, and it is easy to implement with standard econometric packages.

Silva and Tenreyro (2006) reported the results of a cross-sectional Monte-Carlo simulation study designed to assess the performance of the PPML method in the presence of various forms of heteroscedasticity and under various common assumptions about the handling of 'genuine' and 'rounded' zeros, and found PPML to be superior to the OLS, NLS, gamma PML (GPML) and Tobit methods. Finally, they also estimated a cross-sectional gravity equation of aggregate export flows between 136 countries in 1990 without and with exporter- and importer-specific fixed effects and showed that the PPML parameter estimates differ considerably from those generated by other methods, and that all methods but PPML produce some point estimates with illogical signs and bewildering asymmetries between the effects of importer and exporter country characteristics.[18]

Using both aggregated and disaggregated[19] annual trade flow data of 22 OECD countries averaged for the years 1988-1990, Siliverstovs and Schumacher (2008) provided further support to the application of the PPML method in estimating constant-elasticity gravity equations as opposed to the estimation of log-linear gravity equations with OLS. Most importantly, the diagnostic tests performed by Siliverstovs and Schumacher indicated that the assumptions ensuring the consistency of the OLS estimators in the log-linear model are most likely violated, while there are no serious departures from the assumptions underlying the PPML method.

Liu (2007) also warned that if GATT/WTO membership is a catalyst for new trading relationships, then bilateral trade is less likely to be zero between GATT/WTO members than between non-members, so the dismissal of the non-random zero trade flows results in sample selection bias. Still, the fact that Rose (2004) found GATT/WTO ineffective at the intensive margin is puzzling and might indicate the failure of the traditional approach to gravity modeling based on log-linear regressions. According to Liu (2007), the Tobit approach does not resolve this problem because in the presence of non-normal or heteroscedastic errors it might perform even worse than the traditional approach. Instead, the gravity equation should be estimated in its non-linear multiplicative form with NLS, PPLM or GPML and allowance for heteroscedasticity.

The empirical analysis in Liu (2007) was based on a panel data set of real imports of 210 countries or regions from 1948 and 2003.[20] This huge data set was used to estimate a standard gravity equation in various ways: as a pooled log-linear regression, log-linear regression with country-pair fixed and random effects, random effects Probit and Tobit regressions, and Poisson regressions with country-pair fixed and random effects. In order to distinguish the intensive and extensive margins of trade and to illustrate the impact of zero or missing imports on the results, the gravity equations were first estimated from the positive trade flows only, and then from a modified import data set whereby all non-positive (i.e. zero or missing) trade flows were

[17] Silva and Tenreyro (2006, p. 645) readily acknowledge that this assumption might not hold, but consider it a reasonable option in the lack of further information on the exact nature of heteroscedasticity.
[18] Most of the data came from three sources: Feenstra et al. (1997), the World Bank's *World Development Indicators*, and the CIA's *World Factbook*.
[19] Manufacturing products were broken down to 25 three-digit ISIC Rev. 2 industries.
[20] Imports were mainly collected from IFS *Direction of Trade Statistics*, GDP and population were from the *Penn World Tables 5.6* and *6.1*, Maddison's *Historical Statistics*, the IMF *International Financial Statistics*, and from the UN *Statistical Yearbooks*. Most of the remaining data came from the CIA's *World Factbook*.

replaced with zeros.[21] The results from the preferred fixed effects Poisson regression indicated that about one third of the world import can be attributed to the GATT/WTO, and that 30% of this import can be explained by the extensive margin. This latter finding is in stark contrast with the conclusion of Helpman et *al*. (2008) that the extensive margin does not contribute in a major way to the growth of world trade. According to Liu (2007), this discrepancy is mainly due to the fact that the sample period of Helpman et *al*. (2008) is much shorter and excludes the 1950s and 1960s when the growth on the extensive margin was the most prominent.

According to Martin and Pham (2008) the Monte Carlo simulations of Silva and Tenreyro (2006) are suitable for studying the impact of heteroscedasticity on the estimation of gravity models, but they fail to model international trade because the data generating process produced only a small proportion of zeros compared to the actual proportion of zero bilateral trade flows. For this reason, in their simulations Martin and Pham (2008) used a similar data generating process, except that by altering the value of an intercept term and rounding all negative simulated trade flows to zero, the proportion of zeros in their simulated data sets was much higher.[22] The results indicated that the PPML method advocated by Silva and Tenreyro (2006) is indeed the best option for the estimation of gravity models when heteroscedasticity is the only problem, however it performs poorly and yields severely biased estimates when zero trade flows are frequent. The Heckman maximum likelihood estimator appears to cope far better with the joint problem of heteroscedasticity and limited dependent variable bias, as long as the selection and behavioral equations are different and the true identifying restrictions are available. As an illustration, Martin and Pham (2008) borrowed the data set from Silva and Tenreyro (2006) and found that their preferred estimation method yields estimates that are much more similar to the ones obtained from the traditional approaches, like truncated OLS, than to the ones produced by PPML.

To sum up, none of the follow up studies confirmed Rose's bewildering result, but they offer various explanations for the lack of a positive relationship between GATT/WTO membership and bilateral trade, ranging from country selection to various more sophisticated estimation procedures. Although we agree with most of the assessments of these follow up studies, it is still possible that Rose's negative finding is specific to the actual data set he used and to the choice of the dependent variable. We believe that, in spite of all the shortcomings of his methodology brought up in the critiques, the positive impact of GATT/WTO on trade should reveal itself quite straightforwardly. For this reason, we turn our attention to a new, updated international trade data set, which is the topic of the next two sections.

4 A New Data Set

How robust Rose's principal conclusion, i.e. that GATT/WTO membership fails to encourage trade, is to alternative model specifications, estimation methods, and to the choice of modeling average bilateral trade flows or export and import flows separately?[23] According to Rose (2004), the answer for the first and second parts of this question is a definite yes. The third part,

[21] Heteroscedasticy was accounted for by Huber-White standard errors, and in the traditional log-linear regression every trade flow was increased by one.

[22] Depending on the value of the intercept and on the data generating process, the proportion of zeros varied between 40 and 65%.

[23] Although Rose (2004, p. 111) mentioned that "It is possible that GATT/WTO accession has different effects on exports and imports", he did not pursue this idea.

however, cannot be addressed using Rose's downloadable data set[24] because it contains many secondary data but not the original raw data and is therefore unsuitable for three-dimensional (i.e. exporter, importer, and time) analyses. In particular, it has average bilateral trade values, log products of the exporter and importer countries' real GDPs, of real GDPs per capita and of land areas; the numbers of landlocked countries and of island nations in a given pair of countries; and other variables (*ONEIN*, *BOTHIN*, *EVCOL*, *ISCOL*, and *GSP*) which cannot be traced back to the original country specific measurements. Another shortcoming of Rose's data set is that it does not contain zero trade flows so it cannot be used to study the extensive margin of trade. For these reasons we decided to create a new data set. Although we tried to make it as similar to Rose's as possible, there are several important differences between them.

Most of all, while Rose's sample period is 1948-1999, we decided to drop the first dozen years. The reason behind collecting data only from 1960, which coincides with the start of the fifth (Dillon) round of GATT, instead of 1948, was to assure the homogeneity of the measurements as much as possible. As mentioned earlier, Rose obtained the population and GDP data from three different sources, the *Penn World Table*, the World Bank's *World Development Indicators*, and the IMF's *International Financial Statistics*. These data sources, however, are not directly comparable; especially not the first to the other two. By focusing on the sample period from 1960 to 2005 we managed to collect all population and real GDP data from a single source, the 2006 edition of the World Bank's *World Development Indicators* CD-ROM.

Another contentious issue is the Generalized System of Preferences for which it is impossible to obtain comprehensive annual information. Rose compiled his GSP data from three issues of the *Operation and Effects of the Generalized System of Preferences* which contain lists of providers and beneficiaries for various GSP schemes that were known to be in operation in 1974, 1979, and 1984, respectively, and filled in the gaps by arbitrarily extending these GSP preferences backward and forward.[25] These particular unpublished UN pamphlets, however, are unavailable for the 'public', at least searches on the UN and UNCTAD (United Nations Conference on Trade and Development) websites fail to turn up any trace of them. Although we managed to download the 2001 and 2006 versions of the *Generalized System of Preferences – List of Beneficiaries* compiled by UNCTAD, without making some arbitrary assumptions it is not possible to construct annual *GSP* data from them either. Given the uncertainty surrounding *GSP*, we decided to eliminate this variable from our analyses. We also dropped *CNAT* because in Rose's sample it is equal to one in only 0.02% of all cases and, unsurprisingly, this variable always turned out to be insignificant.

Most of the remaining variables are defined the same way in our study than in Rose (2004). The exceptions are

$REXPORT_{ijt}$: Real exports of country *i* to country *j* in year *t* (f.o.b., 2000 US$);
$RIMPORT_{ijt}$: Real imports of country *i* from country *j* in year *t* (c.i.f., 2000 US$).
$LLOCK_i$, $LLOCK_j$: Dummy variables for landlocked country (1 = country *i* (*j*) is landlocked);
$ISLAND_i$, $ISLAND_j$: Dummy variables for island country (1 = country *i* (*j*) is an island nation);
$ISCOL_{ijt}$: Dummy variable for colonizing (1 = country *i* is the colonizer of country *j* in year t);
$EVCOL_{ij}$: Dummy variable for ever colonized (1 = *i* ever colonized *j*);
$GATTWTO_{it}$, $GATTWTO_{jt}$: Dummy variable for GATT/WTO membership (1 = country *i* (*j*) is in GATT/WTO in year *t*).

[24] See: http://faculty.haas.berkeley.edu/arose/RecRes.htm#Software.
[25] The details can be found in endnote # 20 of an unpublished 2003 version of Rose (2004).

From these variables we generated five others: *ART*, *ONEIN*, *BOTHIN*, and the country-pair specific versions of *EVCOL* and *ISCOL*.

Trade flows reported by the exporting countries often differ from the corresponding trade flows reported by the importing countries. The discrepancies are partly due to the fact that exports are usually recorded as f.o.b. and imports as c.i.f. values, but it might also originate from the different qualities of the exporting and importing countries' trade statistics. In any case, gravity model estimates might be sensitive to the choice between export and import flows. According to Piermartini and Teh (2005, p. 46), by and large import data are more reliable than export data. However, since they are based on c.i.f. prices, in import gravity equations distance and all other explanatory variables that are related to transport costs might be correlated with the error term. For this reason we perform all subsequent analyses on exports and import alike.

Most of our updated data came from the same sources as Rose's. In particular, the data on exports and imports were obtained from the December 2006 edition of the IMF's *Direction of Trade Statistics* CD-ROM. These nominal trade values given in US dollars were deflated by the US CPI (all items, city average, 2000 = 100) taken from the December 2006 edition of the IMF's *International Financial Statistics* CD-ROM. The population and real GDP data in constant 2000 US dollars were obtained from the 2006 edition of the World Bank's *World Development Indicators* CD-ROM and then updated from the World Bank's website[26]. The lists of GATT/WTO membership, economic communities and free trade agreements (trade blocks and bilateral trade agreements) were downloaded from the World Trade Organization's website[27] and from *Wikipedia*[28]. Data on colonization were also collected from Wikipedia. The list of mostly spoken languages in each country is from the CIA's *World Factbook*[29]. Distances between trading countries were estimated as the averages of great circle distances (in nautical miles) between 1-3 major cities.[30] Other geographical data, like lists of island countries, landlocked countries, and land borders are from the CIA's *World Factbook* and from *Wikipedia*.

Our data set consists of observations on 27 variables for 180 countries and 46 years (1960-2005). Given this timeframe, there are 1,482,120 cases potentially, but many of them drop out because not all 180 countries existed throughout our sample period. On top of this, the actual size of our data set is primarily limited by the availability of GDP observations; we excluded all cases for which the real GDP of the exporting and/or importing country is not available. For the remaining 947,846 cases the data on the explanatory variables is complete, but there are 275,901 missing *REXPORT* and 274,158 missing *RIMPORT* observations. Unfortunately, we do not have any information about these missing values and it is impossible to tell whether the corresponding countries traded with each other at all. There are also 278,273 zero *REXPORT* and 257,402 zero *RIMPORT* observations, which are either genuine zeros, or are rounded figures and represent nominal flows below half a million US$. This leaves us with 393,672 positive *REXPORT* and 416,286 positive *RIMPORT* observations.

[26] http://web.worldbank.org.
[27] http://www.wto.org.
[28] http://en.wikipedia.org.
[29] https://www.cia.gov/library/publications/the-world-factbook/index.html.
[30] Great circle distances were calculated from latitudes and longitudes of major cities taken from the *Almanacs of Infoplease* (http://www.infoplease.com) using the formula from the web site of *Pearson Software Consulting* (http://www.cpearson.com/excel/latlong.htm).

5 Stylized Facts

Prior to estimating a gravity model similar to (1), we perform some preliminary analyses on our data in order to reveal its characteristics. In particular, we study the relationship between zero and positive trade flows and also between relatively small and large trade flows. In both cases we are interested in reciprocity and persistence, so first we compare the corresponding trades flowing in opposite directions and then the corresponding lagged and current flows.

Unfortunately, as mentioned above, the division between zero and missing trade flows is rather blurred in the existing international data banks. Also recall that the size and structure of our data set are determined by the explanatory variables and the reason behind having omitted a case is that for a particular year one or both real GDP values of the given country pair are unavailable, irrespectively of whether the corresponding export and import flows are known. On the other hand, a missing *REXPORT* or *RIMPORT* observation means that for the given case we have data on all potential explanatory variables but not on the export or import flows. About one third (29%) of our sample belongs to this category.

There is no agreement in the trade literature how to handle the zero and missing trade flows; for example, while Helpman et *al*. (2008) treated zero trade observations as missing values, Felbermayr and Kohler (2006) replaced missing observations with zero trade flows. In this paper we consider the zero and missing trade flows as conceptually different. A zero means that for the given year there was no positive export/import flow recorded between the two countries or that the nominal value of exports/imports was less than half a million US$. As regards the missing values, we accept the lack of information and do not assume that the missing trade flows are equal to zero. Moreover, unlike some other researchers, we do not make any attempt to estimate these missing values either.[31]

Zero versus positive trade flows

In order to check whether zero/positive flows in one direction are independent of zero/positive flows in the opposite direction, we performed chi-square analyses. The results are displayed in *Tables* 2 and 3. The chi-square tests and Cramer's *V* statistics[32] indicate reciprocity of zero trade flows; that is whether in any given year country *i* (*j*) exports to or imports from country *j* (*i*) is not independent of whether country *j* (*i*) exports to or imports from country *i* (*j*). In particular, from *Table* 2, given that country *i* does not export to country *j*, the probability (relative frequency) that country *j* does not export to country *i* either is 0.743 (and given that country *j* does not export to country *i*, the probability that country *i* does not export to country *j* either is 0.665). Likewise, from *Table* 3, the probability of country *j* not importing from country *i*, when country *i* does not import from country *j*, is about 0.627 (the probability of country *i* not importing from country *j*, when country *j* does not import from country *i*, is about 0.693). Consequently, if country *i* (*j*) does not export to or import from country *j* (*i*), it is more likely that *j* (*i*) does not export to or import from *i* (*j*) either.

[31] Missing GDP and trade data is a problem in empirical research in general, but they are particularly hampering in studies focusing on the relationship between international trade and conflicts. For this reason, on the basis of some strong but hardly verifiable assumptions, Gleditsch (2002) attempted to estimate missing data from observations available for similar countries or periods. While in conflict research missing data might indeed constitute a more serious problem than the listwise deletion of all cases where GDP and/or trade flows are unavailable, we still prefer listwise deletion because incorrect assumptions in general might result in seriously biased estimates.

[32] Cramer's *V* is based on chi-square and it measures the strength of association or dependence between two nominal variables in a contingency table.

Table 2: Chi-Square Test on Export Flows from Country *i* to Country *j* and from Country *j* to Country *i*

	$REXPORT_{jit} = 0$	$REXPORT_{jit} > 0$	*Total*
$REXPORT_{ijt} = 0$	80355 (26.6%)	27785 (9.2%)	108140 (35.8%)
$REXPORT_{ijt} > 0$	40477 (13.4%)	153694 (50.8%)	194171 (64.2%)
Total	120832 (40.0%)	181479 (60.0%)	302311 (100%)
Pearson χ^2	82733***	*Cramer's V*	0.523

Note: *** indicates significance at the 1% level.

Table 3: Chi-Square Test on Import Flows to Country *i* from Country *j* and to Country *j* from Country *i*

	$RIMPORT_{jit} = 0$	$RIMPORT_{jit} > 0$	*Total*
$RIMPORT_{ijt} = 0$	68658 (22.7%)	40824 (13.5%)	109482 (36.2%)
$RIMPORT_{ijt} > 0$	30422 (10.1%)	162300 (53.7%)	192722 (63.8%)
Total	99080 (32.8%)	203124 (67.2%)	302204 (100%)
Pearson χ^2	69768***	*Cramer's V*	0.480

Note: *** indicates significance at the 1% level.

We have performed similar analyses on the current and lagged trade flows to find out whether zero/positive flows in year *t*-1 are independent of zero/positive flows in year *t*. The results in *Tables* 4 and 5 imply persistence of no-trade; that is whether country *i* exports to, imports from, or trades with country *j* in year *t* is not independent of whether it did so in year *t*-1. In particular, from *Table* 4, the probability that country *i* does not export to country *j* in year *t* if it did not do so in year *t*-1 is 0.861 (and the probability that country *i* did not export to country *j* in year *t*-1 if it does not do so in year *t* either is 0.887). Likewise, from *Table* 5, the probability that country *i* does not import from country *j* in year *t* if it did not do so in year *t*-1 is 0.844 (and probability that country *i* did not import from country *j* in year *t*-1 if it does not do so in year *t* is 0.871). Hence, we conclude that if a country did not export to or import from another country in year *t*-1, then it is more likely not to do so in year *t* either. Nevertheless, there is still 11-16% chance that from one year to the next a zero bilateral export or import or trade flow between two countries becomes positive, or vice versa.

Table 4: Chi-Square Test on Export Flows from Country *i* to Country *j* in Years *t* and *t*-1

	$REXPORT_{ijt} = 0$	$REXPORT_{ijt} > 0$	*Total*
$REXPORT_{ij,t-1} = 0$	231386 (36.0%)	37499 (5.8%)	268885 (41.8%)
$REXPORT_{ij,t-1} > 0$	29429 (4.6%)	345155 (53.6%)	374584 58.2%
Total	260815 (40.6%)	382654 (59.4%)	643469 (100%)
Pearson χ^2	397091***	*Cramer's V*	0.786

Note: *** indicates significance at the 1% level.

Table 5: Chi-Square Test on Import Flows to Country *i* from Country *j* in Years *t* and *t*-1

	$RIMPORT_{ijt} = 0$	$RIMPORT_{ijt} > 0$	*Total*
$RIMPORT_{it,j-1} = 0$	209593 (32.5%)	38809 (6.0%)	248402 (38.5%)
$RIMPORT_{ij,t-1} > 0$	30910 (4.8%)	365295 (56.7%)	396205 (61.5%)
Total	240503 (37.3%)	404104 (62.7%)	644607 (100%)
Pearson χ^2	382764***	*Cramer's V*	0.771

Note: *** indicates significance at the 1% level.

This conclusion is reinforced by *Figures* 1 and 2. *Figure* 1 shows that the number of zero or positive export and import flows recorded in our data set increased from about 6 thousand in 1960 to about 25 thousand by 2000 and then dropped to about 23 thousand in 2005. On the other hand, *Figure* 2 illustrates the evolution of the proportions of zero export and import flows. Apart from some fluctuations, the relative frequency of zero bilateral trade flows in our sample decreased steadily from about 72-74% in 1960 to 37-40% in 2005. Hence, during our sample period the scope of both the potential and active bilateral trading relationships widened considerably, underlying the importance of the extensive margin of trade.

Small versus large trade flows

Next we turned our attention to the intensive margin of trade and studied the year to year changes and the inertia of the positive trade flows. *Figures* 3 and 4 illustrate the frequency distributions of the first-differences of the logarithms, i.e. the growth rates, of the export and import flows. Both distributions appear to be fairly symmetrical around 0.064 and 0.061, respectively, but the Jarque-Bera tests (not shown here) still reject normality. If we consider a logarithmic change below -2 or above +2, i.e. more than thirty times the mean, as extremely large, then about eight percent of all year to year changes can be classified as 'jumps'.

Figure 1: Number of Bilateral Trade Flows

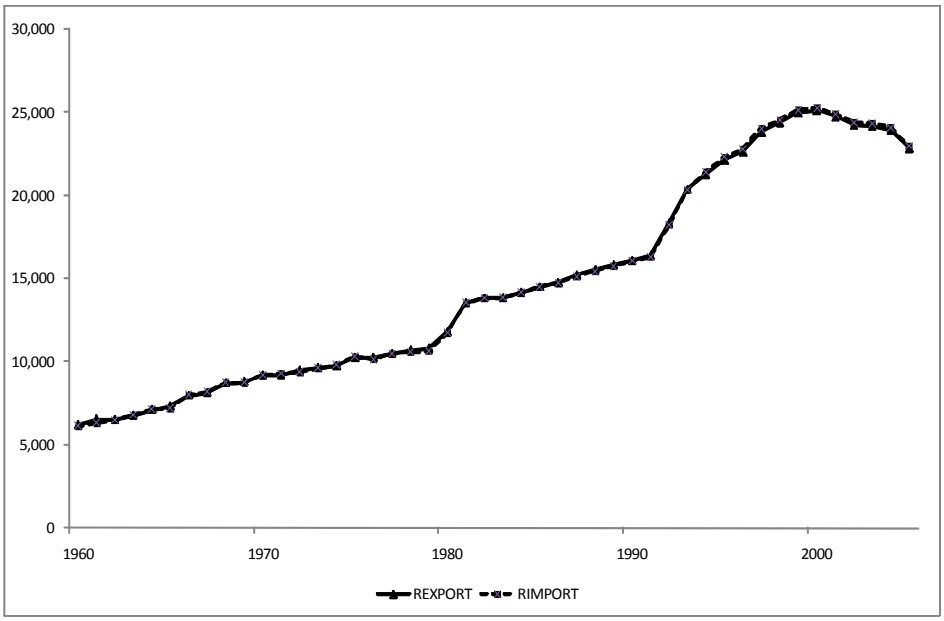


Figure 2: Proportions of Zero Trade Flows

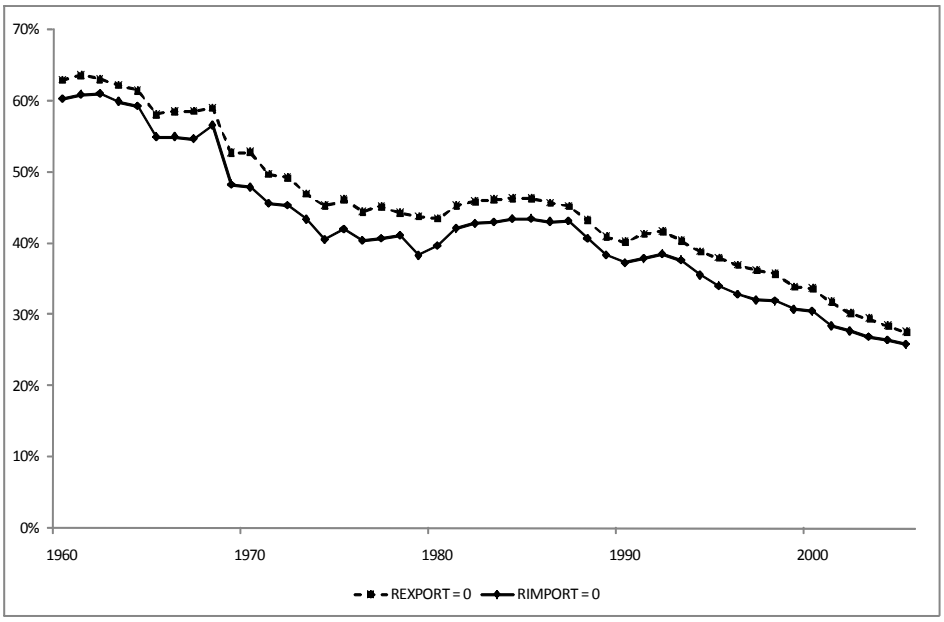


Figure 3: Year to Year Changes of Export Flows

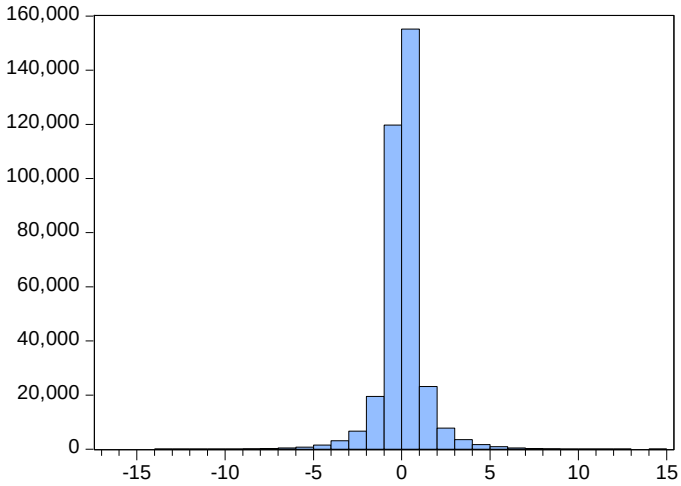
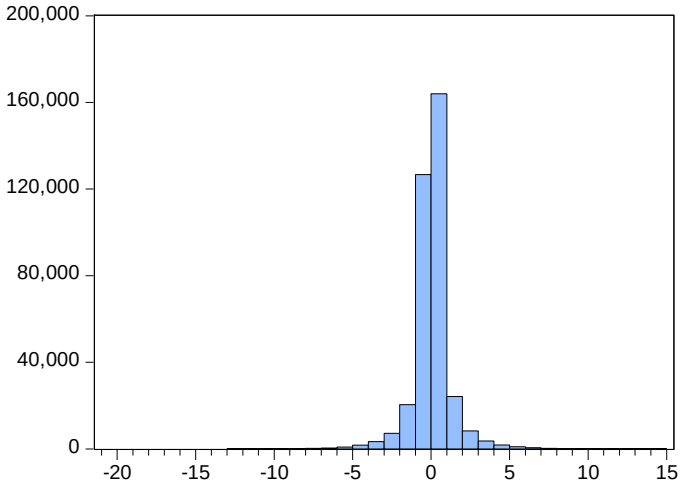


Figure 4: Year to Year Changes in Import Flows



We performed chi-square analyses to see whether the relative magnitudes of the trade flows in one direction are related to the relative magnitudes of the corresponding trade flows in the opposite direction. In order to simplify the task, we classified positive trade flows as 'small' (*S*) or 'large' (*L*), and for any given country pair we defined small and large export and import flows as being below and above the sample mean of *REXPORT* and *RIMPORT*, respectively, in the given relation.

The results in *Tables* 6 and 7 support volume reciprocity; that is whether in any given year country *i*'s exports to or imports from country *j* is small/large is not independent of whether country *j*'s exports to or imports from country *i* is small/large. In particular, from *Table* 6, given that the export flow of country *i* to country *j* is small, the probability that the export flow of country *j* to country *i* is also small is 0.732 (and given that the export flow of country *j* to country *i*

is small, the probability that the export flow of country *i* to country *j* is small too is 0.713). Similarly, from *Table* 7, the probability that the import flow of country *j* from country *i* is small when the import flow of country *i* from country *j* is small is about 0.704 (and the probability that the import flow of country *i* from country *j* is small when the import flow of country *j* from country is small too is about 0.723). Consequently, the relative magnitudes of country *i* 's exports to or imports from country *j* are related to the relative magnitudes of country *j* 's exports to or imports from country *i*. However, judging by the small Cramer's *V* statistics, these relations are rather weak.

Table 6: Chi-Square Tests on Small and Large Export Flows from Country *i* to Country *j* and from Country *j* to Country *i*

	$REXPORT_{ijt} = S$	$REXPORT_{ijt} = L$	*Total*
$REXPORT_{ijt} = S$	108935 (51.8%)	39896 (19.0%)	148831 (70.8)
$REXPORT_{ijt} = L$	43947 (20.9%)	17510 (8.3%)	61457 (29.2%)
Total	152882 (72.7%)	57406 (27.3%)	210288 (100%)
Pearson χ^2	62.241***	*Cramer's V*	0.017

Note: *** indicates significance at the 1% level.

Table 7: Chi-Square Tests on Small and Large Import Flows from Country *i* to Country *j* and from Country *j* to Country *i*

	$RIMPORT_{ijt} = S$	$RIMPORT_{ijt} = L$	*Total*
$RIMPORT_{ijt} = S$	111431 (50.7%)	46861 (21.3%)	158292 (72.0%)
$RIMPORT_{ijt} = L$	42772 (19.5%)	18705 (8.5%)	61477 (28.0%)
Total	154203 (70.2%)	65566 (29.8%)	219769 (100%)
Pearson χ^2	14.288***	*Cramer's V*	0.008

Note: *** indicates significance at the 1% level.

The results in *Tables* 8 and 9 indicate volume persistence; that is whether there is a small or large trade flow between countries *i* and *j* in year *t* is not independent of the size of the trade flow between them in year *t*-1. From *Table* 8, the probability of observing a small export flow from country *i* to country *j* in year *t* when the same flow a year before was small too is 0.874 (and the probability of a small export flow from country *i* to country *j* in year *t*-1, given that the same flow the following year is small too is 0.893). Finally, from *Table* 9, the probability that the import flow of country *j* from country *i* is small in year *t*, given that it was small in year *t*-1 too, is 0.871 (and the probability that the import flow of country *i* from country *j* is small in year *t*-1 if it is also small in year *t* is about 0.889). Therefore, between any two countries, a small (large) trade flow is likely to be followed by a similarly small (large) trade flow.

Table 8: Chi-Square Tests on Positive Export Flows from Country *i* to Country *j* in Years *t* and *t*-1

	$REXPORT_{ijt} = S$	$REXPORT_{ijt} = L$	*Total*
$REXPORT_{ij,t-1} = S$	385796 (64.2%)	55477 (9.2%)	441273 (73.4%)
$REXPORT_{ij,t-1} = L$	46009 (7.6%)	113992 (19.0%)	160001 (26.6%)
Total	431805 (71.8%)	169469 (2.2%)	61274 (100%)
Pearson χ^2	199707***	*Cramer's V*	0.576

Note: *** indicates significance at the 1% level.

Table 9: Chi-Square Tests on Positive Import Flows to Country *i* from Country *j* in Years *t* and *t*-1

	$RIMPORT_{ijt} = S$	$RIMPORT_{ijt} = L$	*Total*
$RIMPORT_{it,j-1} = S$	388243 (63.3%)	57591 (9.4%)	445834 (72.7%)
$RIMPORT_{ij,t-1} = L$	48360 (7.9%)	119290 (19.4%)	167650 (27.3%)
Total	436603 (71.2%)	176881 (28.8%)	613484 (100%)
Pearson χ^2	201374***	*Cramer's V*	0.573

Note: *** indicates significance at the 1% level.

6 Gravity Models

In this section we use our new data set to estimate several versions of a gravity model whose specification is similar to that of equation (1). There is, however, an important difference: since many bilateral trade relations are unbalanced, we study exports and imports separately and we do not restrict the local and partner country characteristics to have identical impact on the bilateral trade between them.

For both dependent variables we consider three regressions. We start with simple OLS regressions; for positive trade flows only, like in Rose (2004), and for all available zero and positive trade flows. Next, we estimate logit regressions for zero versus positive trade flows to see whether the models that explain the magnitudes of trade flows differ from the models that explain the existence of bilateral trade. Finally, we estimate Tobit regressions in order to censor the trade flows from below at zero. Each regression has period fixed effects, but for the sake of brevity, in this paper we report neither them nor the constant term. The reported standard errors are heteroscedasticity consistent standard errors robust to clustering by ordered country pairs.

OLS Regressions

The traditional OLS results for exports and imports are shown in *Table* 10. The dependent variable is the logarithm of exports or imports when only strictly positive trade flows are used,

but each trade flow is increased by one when all available zero and positive trade observations are used in the estimation.

Table 10: OLS Regressions with Period Fixed Effects for Export and Import Flows

Independent Variables	*Coefficient (standard error)*			
	Exports		*Imports*	
	Positive	*All*	*Positive*	*All*
$ONEIN_{ijt}$	**-0.441** (0.077)	**0.578** (0.024)	**-0.359** (0.067)	**0.733** (0.025)
$BOTHIN_{ijt}$	**-0.421** (0.070)	**1.272** (0.025)	**-0.304** (0.055)	**1.434** (0.025)
ln ($RGDP_{it}$)	**1.074** (0.018)	**1.980** (0.005)	**0.955** (0.008)	**1.439** (0.005)
ln ($RGDP_{it}$)	**0.897** (0.010)	**1.565** (0.005)	**1.059** (0.020)	**2.015** (0.005)
ln ($RGDP_{it}$ / POP_{it})	**0.041** (0.007)	**0.206** (0.007)	**-0.059** (0.010)	**0.293** (0.007)
ln ($RGDP_{it}$ / POP_{it})	**-0.067** (0.008)	**0.027** (0.007)	**0.032** (0.005)	**-0.028** (0.007)
ln ($DIST_{ij}$)	**-0.949** (0.016)	**-2.174** (0.010)	**-0.932** (0.018)	**-2.023** (0.010)
ln ($LAND_i$)	**-0.087** (0.003)	**-0.244** (0.004)	**-0.109** (0.003)	**-0.167** (0.004)
ln ($LAND_j$)	**-0.109** (0.004)	**-0.165** (0.004)	**-0.083** (0.002)	**-0.209** (0.004)
$CLANG_{ij}$	**0.364** (0.026)	**0.658** (0.016)	**0.344** (0.027)	**0.618** (0.016)
$CBORD_{ij}$	**0.989** (0.062)	**1.674** (0.049)	**0.905** (0.064)	**1.448** (0.049)
$LLOCK_i$	**0.040** (0.018)	**0.286** (0.020)	**-0.229** (0.030)	**0.077** (0.020)
$LLOCK_j$	**-0.465** (0.020)	**-0.568** (0.019)	**-0.032** (0.016)	0.036 (0.019)
$ISLAND_i$	**-0.031** (0.012)	**0.059** (0.018)	-0.015 (0.017)	**0.203** (0.018)
$ISLAND_j$	**0.049** (0.010)	**0.174** (0.019)	**0.065** (0.018)	**0.282** (0.019)
$EVCOL_{ij}$	**0.812** (0.034)	**1.599** (0.077)	**1.150** (0.024)	**2.757** (0.077)
$COMCOL_{ij}$	**0.284** (0.019)	**1.138** (0.021)	**0.359** (0.017)	**1.123** (0.021)
$ISCOL_{ijt}$	**0.762** (0.091)	**-1.237** (0.338)	**0.924** (0.094)	-0.285 (0.338)
$MUNI_{ijt}$	**1.138** (0.086)	**1.906** (0.042)	**1.057** (0.084)	**1.619** (0.042)
RTA_{ijt}	**0.771** (0.025)	**1.152** (0.025)	**0.746** (0.026)	**1.085** (0.025)
R^2	0.630	0.544	0.642	0.533
n	393672	671945	416286	673688

Note: a) The dependent variable is *ln*(*REXPORT*) or *ln*(*RIMPORT*) for positive trade flows and *ln*(*REXPORT*+1) or *ln*(*RIMPORT*+1) for all available, i.e. zero and positive trade flows.

b) The sample period is from 1960 through 2005, the number of countries is 180, and *n* denotes the sample size. Slope estimates in bold are significant at the five percent level. The intercepts and the period fixed effects, which are jointly significant at any reasonable significance level in every case, are omitted from this table. The estimated standard errors in parentheses are White cross-section standard errors.

It is clear at the first sight that the zero trade observations are crucial; the OLS results based on the strictly positive trade flows are markedly different from the ones based on all available trade flows. The most profound discrepancy is that while in the first case, quite inexplicably, the coefficients of *ONEIN* and *BOTHIN* are both significantly negative, i.e. GATT/WTO membership appears to generate a negative impact on exports and imports, in the second case these

coefficients are significantly positive. For this reason, despite the uncertainties surrounding the zero trade observations, from now on always the full sample is used.

The export and import regressions estimated from all available observations are quite similar to each other qualitatively; except that, ceteris paribus, the partner country's real GDP per capita appears to have a positive impact on the bilateral export flow but a negative impact on the import flow, the export to a landlocked partner country is likely smaller while the import from a landlocked country is likely larger than the export to or the import from a similar country which has direct access to sea, and that a current colonial relationship seems to have no significant impact on the imports of the colonizer from the colony, but reduces the exports of the colonizer to the colony. Although this latter finding is dubious, none of the other significant coefficients has an illogical sign.

The coefficients of *ONEIN* and *BOTHIN* are not only significant, but fairly large. They suggest that, ceteris paribus, exports are about 78% higher between a member and a non-member country and 257% higher between two member countries than between two non-member countries; and similarly, imports are about 108% higher between a member and a non-member country and 420% higher between two member countries than between two non-member countries.

In order to compare the relative contributions of the regressors to the explanations of the regressands, we have also calculated the beta coefficients, i.e. the regression coefficients on standardized variables. They are shown in *Table* 11. Apparently, exports and imports are primarily determined by the real GDPs of the partner countries and by the geographical distance between them. The next most important factor is whether both countries are members of the GATT/WTO, but even the fact that one of them is a member country seems to be more important than such traditional gravity variables as *CBORD*, *LLOCK*, *ISLAND*, or *EVCOL*, *ISCOL*.

Recall that, similarly to Rose (2004), we deflated all bilateral nominal export and import data with the US consumer price index for all items averaged across all major cities, irrespectively of the partner countries. This is clearly not an ideal solution, but it would be an enormous task to apply country or country-pair specific deflators. It is possible, though, to use other deflators which are probably more appropriate to many economies than US CPI. To this end, we have experimented with four alternative deflators: the price index for emerging and developing economies, and the world commodity price indices for metals, food, and agricultural raw materials, respectively.[33] Our results, however, do not change qualitatively, the coefficients of *ONEIN* and *BOTHIN* are still significantly positive, though they are 2 to 14 percent smaller than the ones reported in *Table* 10.[34]

We have performed Wald tests on each regression to check whether the corresponding local and target country coefficients significantly differ and found that when both coefficients are significant individually they are significantly different from each other as well, supporting our decision not to impose equality on them.[35]

[33] These price indices were obtained from the December 2006 edition of the IMF's *International Financial Statistics* CD-ROM.
[34] To keep this paper reasonably short, we do not show these results but they are available on request.
[35] These results are not reported in this paper either.

Table 11: Beta Coefficients from the OLS Regressions with Period Fixed Effects for Export and Import Flows

Independent Variables	*Exports*	*Imports*
$ONEIN_{ijt}$	**0.081**	**0.100**
$BOTHIN_{ijt}$	**0.181**	**0.199**
ln ($RGDP_{it}$)	**1.296**	**0.921**
ln ($RGDP_{jt}$)	**1.041**	**1.304**
ln ($RGDP_{it}$ / POP_{it})	**0.092**	**0.128**
ln ($RGDP_{jt}$ / POP_{jt})	**0.012**	**-0.012**
ln ($DIST_{ij}$)	**-0.487**	**-0.441**
ln ($LAND_i$)	**-0.161**	**-0.108**
ln ($LAND_j$)	**-0.111**	**-0.136**
$CLANG_{ij}$	**0.090**	**0.083**
$CBORD_{ij}$	**0.070**	**0.059**
$LLOCK_i$	**0.029**	**0.008**
$LLOCK_j$	**-0.059**	0.004
$ISLAND_i$	**0.007**	**0.023**
$ISLAND_j$	**0.020**	**0.032**
$EVCOL_{ij}$	**0.040**	**0.069**
$COMCOL_{ij}$	**0.114**	**0.109**
$ISCOL_{ijt}$	**-0.007**	-0.002
$MUNI_{ijt}$	**0.088**	**0.074**
RTA_{ijt}	**0.089**	**0.081**

Note: The beta coefficients are the coefficients in a regression on standardized variables. Numerically, the beta coefficient of a regressor is equal to the original regression coefficient multiplied by the ratio of the sample standard deviation of the regressor to the sample standard deviation of the regressand.

Nevertheless, for the sake of comparison, we also estimated Rose's specification. The results in *Table* 12 lend further support to the expected positive impact of GATT/WTO membership on bilateral trade. In fact, compared to the separate export and import regressions, this impact appears to be even larger, while the effects of the other regressors are smaller.

The Logit Aproach

As seen in *Table* 10, the gravity models estimated exclusively from positive trade flows are inexplicable, calling for the consideration of the extensive margin of trade as well. First we modeled the magnitude of bilateral trade, now we turn our attention to the factors that contribute to the existence of bilateral trade.

We created two dummy variables, *REXPORT_CODE* and *RIMPORT_CODE*, for positive vs. zero export and import flows, and estimated binary logit models with period fixed effects. The results, summarized in *Table* 13, are very similar qualitatively to the OLS results, except that this time all coefficients are significant. Therefore, all independent variables contribute to switches from zero flows to positive flows and vice versa, but not equally. According to the beta

coefficients, the switches are primarily determined by the real GDPs of the partner countries, by the geographical distance between them, and by GATT/WTO membership.

Table 12: OLS Regression with Period Fixed Effects for Average Bilateral Trade Flows

Dependent Variable: $\ln ART_{ijt}$	*Coefficient (standard error)*
$ONEIN_{ijt}$	**0.773** (0.101)
$BOTHIN_{ijt}$	**1.464** (0.118)
$\ln (RGDP_{it} \times RGDP_{jt})$	**1.650** (0.012)
$\ln (RGDP_{it} / POP_{it} \times RGDP_{jt} / POP_{jt})$	**0.079** (0.026)
$\ln DIST_{ij}$	**-1.894** (0.029)
$\ln (LAND_i \times LAND_j)$	**-0.175** (0.007)
$CLANG_{ij}$	**0.493** (0.046)
$CBORD_{ij}$	**1.290** (0.061)
$NLLOCK_{ij}$	**-0.350** (0.057)
$NISLAND_{ij}$	**0.182** (0.043)
$EVCOL_{ij}$	**1.327** (0.115)
$COMCOL_{ij}$	**1.065** (0.075)
$ISCOL_{ijt}$	-0.543 (0.410)
$MUNI_{ijt}$	**1.385** (0.169)
RTA_{ijt}	**1.047** (0.097)
R^2	0.571
n	376762

Note: a) The sample period is from 1960 through 2005, the number of countries is 180.
b) The intercept and the period fixed effects, which are jointly significant at any reasonable significance level, are not reported in this table. Slope estimates in bold are significant at the 5 percent level. The numbers in the parentheses are White cross-section standard errors.

The logit coefficients of *ONEIN* and *BOTHIN* are both significantly positive, that is the estimated probability of two countries trading with each other increases by the number of GATT/WTO members in the dyad.

It is also edifying to compare the sub-samples of zero and positive export and import flows in terms of the corresponding relative moves in the regressors. *Table* 14 displays the sample means of the independent variables for zero and positive export and import flows, respectively, and the relative differences between the corresponding sample means. Depending on whether

this latter measurement is above 100%, between 40 and 100%, or below 40%, the independent variables fall into three groups. The first group includes *CBORD* and *EVCOL*, and the second group consists of *BOTHIN* and *RTA*. These variables exhibit the largest relative change between the sub-samples of zero and positive trade flows, that is they help most categorize them. The remaining sixteen variables belong to the third group.

Table 13: Logit Results with Period Fixed Effects for Export and Import Flows

Independent Variables	*Exports*		*Imports*	
	Coefficient (std. error)	*Beta coefficient*	*Coefficient (std. error)*	*Beta coefficient*
$ONEIN_{ijt}$	**0.330** (0.012)	**0.329**	**0.362** (0.012)	**0.366**
$BOTHIN_{ijt}$	**0.665** (0.012)	**0.674**	**0.697** (0.012)	**0.717**
ln ($RGDP_{it}$)	**0.705** (0.003)	**3.296**	**0.442** (0.003)	**2.101**
ln ($RGDP_{jt}$)	**0.540** (0.003)	**2.565**	**0.700** (0.003)	**3.365**
ln ($RGDP_{it}$ / POP_{it})	**0.102** (0.003)	**0.327**	**0.193** (0.003)	**0.629**
ln ($RGDP_{jt}$ / POP_{jt})	**0.056** (0.003)	**0.179**	**-0.008** (0.003)	**-0.026**
ln ($DIST_{ij}$)	**-0.909** (0.005)	**-1.453**	**-0.805** (0.005)	**-1.304**
ln ($LAND_i$)	**-0.101** (0.002)	**-0.475**	**-0.053** (0.002)	**-0.254**
ln ($LAND_j$)	**-0.058** (0.002)	**-0.278**	**-0.084** (0.002)	**-0.407**
$CLANG_{ij}$	**0.226** (0.008)	**0.222**	**0.214** (0.008)	**0.213**
$CBORD_{ij}$	**0.903** (0.032)	**0.271**	**0.741** (0.031)	**0.224**
$LLOCK_i$	**0.174** (0.010)	**0.124**	**0.126** (0.010)	**0.092**
$LLOCK_j$	**-0.160** (0.009)	**-0.119**	**0.056** (0.009)	**0.042**
$ISLAND_i$	**0.034** (0.009)	**0.029**	**0.095** (0.009)	**0.081**
$ISLAND_j$	**0.061** (0.009)	**0.051**	**0.129** (0.009)	**0.109**
$EVCOL_{ij}$	**1.057** (0.074)	**0.191**	**1.430** (0.065)	**0.265**
$COMCOL_{ij}$	**0.472** (0.011)	**0.337**	**0.436** (0.010)	**0.316**
$ISCOL_{ijt}$	**-1.711** (0.162)	**-0.069**	**-1.047** (0.162)	**-0.043**
$MUNI_{ijt}$	**0.772** (0.023)	**0.255**	**0.620** (0.023)	**0.209**
RTA_{ijt}	**0.629** (0.014)	**0.346**	**0.576** (0.014)	**0.321**
R^2	0.358		0.333	
n	671945		673,688	

Note: a) The sample period is from 1960 through 2005, the number of countries is 180.
b) The intercepts and the period fixed effects, which are jointly significant at any reasonable significance level in every case, are omitted from this table. The estimated standard errors are in parentheses. Slope estimates in bold are significant at the 5 percent level.
c) The dependent variable is *REXPORT_CODE* and *RIMPORT_CODE*, dummy variables for positive/zero export and import flows, respectively.
e) R^2 denotes McFadden's R^2.

Table 14: Sample Means of the Explanatory Variables in the Logit Regressions

Independent Variables	***Dependent Variable***							
	REXPORT_CODE				*RIMPORT_CODE*			
	0	1	All	Rel. diff.	0	1	All	Rel. diff.
$ONEIN_{ijt}$	0.478	0.364	0.411	41	0.480	0.368	0.411	27
$BOTHIN_{ijt}$	0.378	0.582	0.498	28	0.371	0.577	0.498	41
$\ln(RGDP_{it})$	22.297	24.218	23.423	8	22.598	23.906	23.406	6
$\ln(RGDP_{jt})$	22.429	23.884	23.290	6	22.093	24.052	23.303	8
$\ln(RGDP_{it} / POP_{it})$	7.060	8.003	7.612	12	7.158	7.897	7.615	10
$\ln(RGDP_{jt} / POP_{jt})$	7.186	7.848	7.574	9	7.056	7.894	7.574	11
$\ln(DIST_{ij})$	8.292	7.991	8.115	4	8.286	8.010	8.116	3
$\ln(LAND_i)$	11.638	12.094	11.905	4	11.781	11.965	11.895	2
$\ln(LAND_j)$	11.629	12.009	11.851	3	11.478	12.094	11.859	5
$CLANG_{ij}$	0.364	0.379	0.373	4	0.363	0.377	0.372	4
$CBORD_{ij}$	0.006	0.034	0.022	122	0.007	0.032	0.022	110
$LLOCK_i$	0.165	0.131	0.145	24	0.161	0.138	0.147	16
$LLOCK_j$	0.189	0.140	0.160	30	0.193	0.139	0.160	34
$ISLAND_i$	0.252	0.198	0.220	25	0.235	0.212	0.221	11
$ISLAND_j$	0.243	0.202	0.219	19	0.252	0.196	0.217	26
$EVCOL_{ij}$	0.001	0.013	0.008	142	0.002	0.012	0.008	128
$COMCOL_{ij}$	0.150	0.141	0.145	6	0.151	0.141	0.145	7
$ISCOL_{ijt}$	0.000	0.000	0.000	39	0.000	0.000	0.000	32
$MUNI_{ijt}$	0.021	0.032	0.027	39	0.023	0.031	0.028	29
RTA_{ijt}	0.046	0.120	0.089	83	0.046	0.115	0.089	77

Note: Relative difference for a given variable is the ratio of the difference between its sub-sample means to its overall sample mean.

The Tobit Approach

In our sample about 40 percent of all non-missing trade flows are equal to zero. In the light of this high proportion of zeros, next we estimated Tobit regressions based on left censoring at zero.[36] The results are shown in *Table* 15. All but one or two independent variables are significant in both models, including *ONEIN* and *BOTHIN* which have positive impact on trade.[37]

The export and import regressions are again similar to each other qualitatively, apart from three differences. Namely, the partner country's real GDP per capita is insignificant in the export regression but has a significantly negative coefficient in the import regression, whether the partner country is landlocked has a significantly negative coefficient in the export regression but

[36] Since the dependent variable is still *ln*(*REXPORT*+1) or *ln*(*RIMPORT*+1), this censoring occurs at *REXPORT* = 0 or *RIMPORT* = 0.

[37] Rose (2004) also estimated a Tobit regression, but still rejected any economically substantial effect of the GATT/WTO on trade. As mentioned earlier, his data set does not contain zero trade flows so he could experiment with Tobit regression only by replacing the smallest 5 percent of the sample trade observations by zero. This proportion of zeros, however, is far too low and makes Rose's conclusion doubtful.

is insignificant in the import regression, and being colonized appears insignificant in the export regression but has a significantly positive coefficient in the import regression.

Table 15: Tobit Results with Period Fixed Effects for Export and Import Flows

Independent Variables	*Exports*		*Imports*	
	Coefficient (std. error)	*Beta coefficient*	*Coefficient (std. error)*	*Beta coefficient*
$ONEIN_{ijt}$	**2.118** (0.049)	**0.130**	**2.231** (0.046)	**0.139**
$BOTHIN_{ijt}$	**3.046** (0.049)	**0.191**	**3.178** (0.046)	**0.201**
ln ($RGDP_{it}$)	**2.981** (0.009)	**0.860**	**1.979** (0.008)	**0.579**
ln ($RGDP_{jt}$)	**2.291** (0.009)	**0.671**	**2.887** (0.008)	**0.854**
ln ($RGDP_{it}$ / POP_{it})	**0.231** (0.011)	**0.046**	**0.444** (0.011)	**0.089**
ln ($RGDP_{jt}$ / POP_{jt})	0.009 (0.011)	0.002	**-0.130** (0.011)	**-0.026**
ln ($DIST_{ij}$)	**-3.197** (0.016)	**-0.315**	**-2.822** (0.015)	**-0.281**
ln ($LAND_i$)	**-0.347** (0.007)	**-0.101**	**-0.207** (0.007)	**-0.061**
ln ($LAND_j$)	**-0.228** (0.007)	**-0.067**	**-0.287** (0.007)	**-0.086**
$CLANG_{ij}$	**0.948** (0.026)	**0.057**	**0.840** (0.025)	**0.051**
$CBORD_{ij}$	**2.123** (0.078)	**0.039**	**1.825** (0.075)	**0.034**
$LLOCK_i$	**0.478** (0.034)	**0.021**	**0.129** (0.032)	**0.006**
$LLOCK_j$	**-0.919** (0.033)	**-0.042**	0.019 (0.031)	0.001
$ISLAND_i$	**-0.078** (0.030)	**-0.004**	**0.219** (0.029)	**0.012**
$ISLAND_j$	**0.111** (0.031)	**0.006**	**0.172** (0.029)	**0.009**
$EVCOL_{ij}$	**0.686** (0.111)	**0.008**	**2.908** (0.109)	**0.027**
$COMCOL_{ij}$	**2.090** (0.036)	**0.092**	**1.938** (0.034)	**0.070**
$ISCOL_{ijt}$	0.859 (0.566)	0.002	**1.667** (0.547)	**0.004**
$MUNI_{ijt}$	**2.638** (0.071)	**0.054**	**2.074** (0.067)	**0.035**
RTA_{ijt}	**0.882** (0.040)	**0.030**	**0.795** (0.038)	**0.022**

Note: a) The sample period is from 1960 through 2005, the number of countries is 180, and the number of observations is 671,945 for *Exports* and 673,688 for *Imports*.

b) The intercepts and the period fixed effects, which are jointly significant at any reasonable significance level in every case, are omitted from this table. The estimated standard errors are in parentheses. Slope estimates in bold are significant at the 5 percent level.

c) Left censoring at zero. The number of left censored observations is 278,273 for *Exports* and 257,402 for *Imports*, while the number of uncensored observations is 393,672 for *Exports* and 416,286 for *Imports*, respectively.

The Tobit coefficients lead to the same conclusion as the OLS and logit coefficients. Namely, the most important factors behind bilateral exports and imports are the real GDPs of the partner countries, the geographical distance between them, and their GATT/WTO membership. Finally, the sample means of the regressors for the censored and uncensored cases are in *Table* 16. Just like in the logit regressions, *CBORD*, *EVCOL*, *BOTHIN* and *RTA* exhibit the largest relative difference between the two sub-samples, so probably they help most separate them.

Table 16: Sample Means of the Explanatory Variables in the Tobit Regressions

Independent Variables	***Export Equation***				***Import Equation***			
	Cens.	Not cens.	All	Rel. diff.	Cens.	Not cens.	All	Rel. diff.
$ONEIN_{ijt}$	0.478	0.364	0.411	28	0.480	0.368	0.411	27
$BOTHIN_{ijt}$	0.378	0.582	0.498	41	0.371	0.577	0.498	41
$\ln(RGDP_{it})$	22.297	24.218	23.423	8	22.598	23.906	23.406	6
$\ln(RGDP_{it})$	22.449	23.884	23.290	6	22.093	24.052	23.303	8
$\ln(RGDP_{it} / POP_{it})$	7.060	8.003	7.612	12	7.158	7.897	7.615	10
$\ln(RGDP_{it} / POP_{it})$	7.186	7.848	7.574	9	7.056	7.894	7.574	11
$\ln(DIST_{ij})$	8.292	7.991	8.115	4	8.286	8.010	8.116	3
$\ln(LAND_i)$	11.638	12.094	11.905	4	11.781	11.965	11.895	2
$\ln(LAND_j)$	11.629	12.009	11.851	3	11.478	12.094	11.859	5
$CLANG_{ij}$	0.364	0.379	0.373	4	0.363	0.377	0.372	4
$CBORD_{ij}$	0.006	0.034	0.022	122	0.007	0.032	0.022	110
$LLOCK_i$	0.165	0.131	0.145	24	0.161	0.138	0.147	16
$LLOCK_j$	0.189	0.140	0.160	30	0.193	0.139	0.160	34
$ISLAND_i$	0.252	0.198	0.220	25	0.235	0.212	0.221	11
$ISLAND_j$	0.243	0.202	0.219	19	0.252	0.196	0.217	26
$EVCOL_{ij}$	0.001	0.013	0.008	142	0.002	0.012	0.008	128
$COMCOL_{ij}$	0.150	0.141	0.145	6	0.151	0.141	0.145	7
$ISCOL_{ijt}$	0.000	0.000	0.000	39	0.000	0.000	0.000	32
$MUNI_{ijt}$	0.021	0.032	0.027	39	0.023	0.031	0.028	29
RTA_{ijt}	0.046	0.120	0.089	83	0.046	0.115	0.089	77

Note: Relative difference for a given variable is the ratio of the difference between its sub-sample means to its overall sample mean.

7 Conclusion

On the basis of close to eighty variants of a standard gravity model of bilateral trade estimated for 175 countries over 1948 and 1999, Rose (2004, p. 112) concluded that “Even if one believes that the GATT/WTO acts as an immeasurable trade-promoting externality, we do not *know* that the multilateral system has stimulated trade.” Since this finding is inconsistent with the fact that many countries are ready to pay huge “price” for membership, it is not surprising that it invited many criticisms concerning, for example, pooling developed and developing countries, not discerning non-member countries that are bound by GATT/WTO agreements, ignoring relative trade barriers, potential endogeneity bias, considering only the intensive margin of trade, and the log-linearized specification of Rose’s model.

Although most of these criticisms are pertinent, in our opinion the key problem is that Rose’s data set contains only positive average trade flows. To rectify this shortcoming, we set up a new international trade data set, mostlyfrom the same sources asRose, which contains zeros as well and also separate bilateral export and import flows. Our preliminary analysis of this new data set demonstrated that bilateral trade, despite being often unbalanced, tends to be reciprocal and persistent. It also highlighted the importance of the extensive margin of trade.

Using a similar specification to Rose's, we estimated ordinary least squares (OLS), logit and Tobit gravity models. For the sake of comparison, in the first case we used not only the full sample but the sub-sample of the strictly positive export, import flows too. However, the OLS gravity equation estimated from this sub-sample does not make much sense because it implies that GATT/WTO membership has a negative impact on international trade. On the other hand, the OLS, tobit and Logit gravity equations estimated from all available zero and positive trade observations unequivocally imply that GATT/WTO membership encourages international trade, both among member countries and with non-member countries. Although our study differs from Rose's, both in terms of the sample and model specification, the conflicting results based on the positive flows and on all flows suggest that Rose's negative finding is most likely due to his ignorance of zero bilateral trade flows, supporting the criticisms of Helpman et *al*. (2008) and Felbermayr and Kohler (2006).

Finally, we readily acknowledge that many criticisms directed towards Rose (2004) are valid to our gravity equations too. We do not dispute, for example, that the two-stage strategy of Helpman et *al*. (2008) or the Poisson pseudo-maximum likelihood method of Silva and Tenreyro (2006) are superior. We believe, however, that despite their shortcomings, the traditional OLS, tobit and Logit approaches are also sufficient to detect the positive impact of GATT/WTO on trade, granted that the data set is informative enough.

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