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Does the GATT/WTO promote trade? After all, Rose was right

Silviano Esteve-Pérez[1] · **Salvador Gil-Pareja**[1,2] · **Rafael Llorca-Vivero**[1]

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Abstract

This paper re-examines the effect of the GATT/WTO on trade using recent econometric developments that allow us estimating structural gravity equations with the Poisson pseudo-maximum likelihood (PPML) estimator on a large dataset that requires computing high-dimensional fixed effects. By doing so, we overcome computational limitations that are present in previous studies. In line with Rose's (Am Econ Rev 94:98–114, 2004) seminal work, we find that, unlike regional trade agreements and currency unions, the GATT/WTO accession has not generated positive trade effects. This result is robust to the use of alternative measures of trade flows, across periods and country groups, to changes in the periodicity of the data, when taking into account the GATT/WTO accession dynamics, to controlling for the participation of only one country of the dyad in GATT/WTO, to the consideration of non-member participants, and to the use of alternative datasets. Notwithstanding, we also find that PPML results are sensitive to the definition of the dependent variable.

Keywords GATT/WTO · Trade · Gravity model · PPML · High-dimensional fixed effects

JEL Classification F13 · F14

1 Introduction

Over the last 70 years the GATT and its successor from 1995, the WTO, have sponsored nine rounds of trade-policy negotiations that have successfully reduced trade barriers and contributed to a more transparent and predictable environment for world trade. Up to the early 2000s there was a broad consensus on the important

✉ Salvador Gil-Pareja
Salvador.Gil-Pareja@uv.es

1 University of Valencia and Inteco Research Unit, Valencia, Spain

2 Facultad de Economía, Departamento de Estructura Económica, Av. de los Naranjos s/n, 46022 Valencia, Spain

role played by GATT/WTO in promoting international trade. However, in a seminal empirical contribution, Rose (2004) reported the striking finding that countries acceding or belonging to the GATT/WTO did not have significantly different trade patterns than non-members. This contradiction between the conventional view and Rose's results led him to describe this finding as an "interesting mystery" (p. 112) that deserved further research. Ever since, a considerable number of studies have attempted to solve this puzzle by updating Rose's dataset, accounting for potential sources of omitted variables bias, using alternative econometric techniques, taking into account the margins of trade (extensive and intensive) or splitting the sample by groups of countries, periods and sectors.

A review of the literature reveals that there has been an intense debate on this issue over more than a decade.[1] The empirical work relies on different specifications of the gravity equation. While some papers confirm Rose's finding (Eicher and Henn 2011; Roy 2011), and there exists a large heterogeneity in the results across group of countries and periods, most papers find that, as a whole, the GATT/WTO has had a trade promoting effect in line with the aforementioned consensus view. Tomz et al. (2007), Liu (2009), Chang and Lee (2011), Herz and Wagner (2011), Dutt et al. (2013), Cheong et al. (2014), Kohl and Trojanowska (2015), Kohl (2015), and Gil-Pareja et al. (2016) find evidence of such a trade-enhancing effect. Moreover, other papers find evidence of a positive effect but limited to some groups of countries, sectors or periods (Subramanian and Wei 2007; Felbermayr and Kohler 2010; and Bista 2015).[2]

In parallel with this literature, several authors have focused on seeking the proper econometric specification for the gravity equation. Glick and Rose (2002), Egger and Pfaffermayr (2003), Chen and Wall (2005) or Baier and Bergstrand (2007) illustrate the importance of including time-invariant country-pair fixed effects to control for unobservable bilateral heterogeneity and endogeneity.[3] Baier and Bergstrand (2007) and Baldwin and Taglioni (2007) suggest that the gravity equation should also include exporter-time and importer-time fixed effects to control for changes in multilateral resistance terms (Anderson and van Wincoop 2003). Last but not least, Santos Silva and Tenreyro (2006, 2010a) propose to use the Pseudo-Maximum

[1] See Gil-Pareja et al. (2016) for a comprehensive review of the empirical literature on the effect of GATT/WTO on trade.

[2] Subramanian and Wei (2007) conclude that the GATT/WTO promotes trade strongly, but unevenly. In particular, they find that the GATT/WTO boosts trade in industrialized countries, but not in developing countries; in less protected sectors, but not in agriculture and textile sectors; and for new WTO members, but not for old GATT members. Moreover, Felbermayr and Kohler (2010) document a positive effect on trade for developing country importers in the post-Uruguay Round era. Finally, Bista (2015) finds a positive impact but only on the extensive margin in trade between industrial and developing members.

[3] Since Baier and Bergstrand (2007) pointed out that trade agreements are not exogenous, the endogeneity issue has received a great deal of attention in the empirical gravity-equation literature. These authors proposed the inclusion of country-pair fixed effects to deal with this problem. However, it is worth noting that country-pair dummies do not completely eliminate the extent of endogeneity. Therefore, this paper will test for strict exogeneity in Sect. 4.

Likelihood estimator (PPML, hereafter) to deal with econometric problems resulting from heteroskedastic residuals and the prevalence of zeros in bilateral trade flows.[4]

Despite the fact that the available empirical literature on the effect of GATT/WTO on trade has progressively improved the econometric specifications to account for potential sources of bias, computational issues have so far conditioned the choice of estimator. The large datasets used in the estimation of the GATT/WTO effect (requiring to compute three different types of high-dimensional fixed effects) and/or difficulties to achieve convergence have precluded accounting simultaneously for unobserved bilateral heterogeneity and endogeneity (with country-pair fixed effects), multilateral resistance terms (with exporter-time and importer-time fixed effects), heteroskedastic residuals and zero trade flows.[5] However, recently Correia et al. (2019) have provided a new Stata command (*ppmlhdfe*) for fast estimation of (pseudo) Poisson regression models with multiple high dimensional fixed effects, allowing accounting for all above issues in large datasets.[6]

This paper uses the computational development brought about by Correia et al. (2019) to estimate for the first time, to the best of our knowledge, the GATT/WTO effect on trade using the PPML estimator with the aforementioned three types of (high-dimensional) fixed effects. We carry out the estimations employing a dataset that includes trade flows between more than 200 countries over the period 1948–2013. Therefore, we need to compute more than 50,000 fixed effects to obtain unbiased and theory-consistent estimates.

Our findings suggest that when we estimate the gravity equation with PPML including the full set of high-dimensional fixed effect, the (direct) positive GATT/WTO trade effect vanishes, which is in line with Rose (2004). Interestingly, in contrast to the results for the GATT/WTO, we find strong support for the positive effect of regional trade agreements and currency unions on bilateral trade flows. This result holds using different measures of trade flows, across country groups and time periods for alternative classification criteria, and when including lags in the regression. The results are also robust to changes in the periodicity of the data, to controlling for the participation of only one country in GATT/WTO and to accounting for nonmember participants *à la* Tomz et al. (2007), as well as to the use of alternative datasets. It is worth noting that these results are based on total trade flows, which put more weight on large bilateral trade flows and possibly hide positive effects for

[4] Some recent papers (see, for example, Dai et al. 2014; Bergstrand et al. 2015; Anderson and Yotov 2016; Baier et al. 2016; Mattoo et al. 2017) show the importance of including the internal trade flows in the estimation of the gravity equation of international trade. In this paper, we do not include within-country trade flows due to the lack of the required data (in terms of both countries and years of analysis).

[5] In this literature, five papers account for both heteroskedastic residuals and zeros using Poisson estimators (Liu 2009; Felbermayr and Kohler 2010; Herz and Wagner 2011; Bista 2015; Gil-Pareja et al. 2016) but none of them simultaneously controls for unobserved bilateral heterogeneity and multilateral resistance terms.

[6] In a previous version of this paper, we used the Zylkin's *ppml_panel_sg* Stata command. Larch et al. (2019) apply this command on the Glick and Rose (2016) dataset (as we do here) to re-assess the currency union effect on trade concluding that whereas the effect of non-euro currency unions is large and significant, the euro effect is economically small and statistically insignificant.

small countries. Indeed, we find evidence in favour of this intuition when we estimate PPML on trade shares.

The rest of the paper is organized as follows. Section 2 presents the methodology. Section 3 describes the data. Section 4 presents and discusses the results and Sect. 5 includes a set of robustness checks. Finally, Sect. 6 concludes.

2 Methodology

Since it was independently developed by Tinbergen (1962) and Pöyhönen (1963) more than five decades ago, the gravity model has become the main econometric approach for the *ex post* estimation of the "partial" (or direct) effects of different kinds of economic integration agreements on bilateral trade, including the GATT/WTO. This paper estimates the PPML estimator using the *ppmlhdfe* Stata command recently developed by Correia et al. (2019). This approach allows us estimating the gravity equation using this methodology on a large dataset requiring to compute three types of high-dimensional fixed effects (exporter-year, importer-year and country-pair) to avoid biased estimates and misleading inference.

Baltagi et al. (2003), Baier and Bergstrand (2007), Baldwin and Taglioni (2007) and Gil-Pareja et al. (2008a, b) motivated and included the three types of fixed effects in the estimation of log-linear gravity equations of international trade. This set of fixed effects deals with two sources of omitted variables bias. On the one hand, country-pair fixed effects control for the impact of any time-invariant determinant of bilateral trade (observed or not) correlated with the regressors.[7] On the other hand, Anderson and van Wincoop (2003), in their theoretical foundation of the gravity equation, highlight that bilateral trade flows depend not only on bilateral trade barriers between any two countries but also on trade barriers of each country with the rest of the trading partners (i.e., the multilateral resistance).[8] They show that omitting a variable that reflects each country's multilateral resistance to trade leads to biased estimates. In a panel data setting, the usual solution to this problem is to include country-year fixed effects for both importers and exporters. Eicher and Henn (2011), Roy (2011), Dutt et al. (2013), Cheong et al. (2014), and Gil-Pareja et al. (2016) have estimated the effect of GATT/WTO on trade using log-linear structural gravity equations that control simultaneously for both unobserved bilateral heterogeneity (with country-pair fixed effects) and multilateral resistance terms (with exporter-time and importer-time fixed effects).

The PPML estimator, initially proposed by Santos Silva and Tenreyro (2006) to fit the gravity model of bilateral trade flows, has two interesting properties when compared to the traditional log-linear gravity regression. First, it avoids the

[7] The argument is that there may be unobserved country-pair characteristics that affect trade, and which are at the same time correlated with the economic integration agreements. Baier and Bergstrand (2007) address this issue with respect to free trade agreements suggesting the use of dyadic fixed effects to avoid this omitted variable bias.

[8] Anderson (1979) and Bergstrand (1985) offer early theoretical justification for the gravity model.

statistical problems that arise from the existence of zero bilateral trade flows.[9] Second, it solves econometric problems that emerge in the presence of heteroskedastic residuals. It is worth pointing out that the existence of heteroskedasticity affects both the efficiency and the consistency of an estimator and, as Santos Silva and Tenreyro (2006) emphasize, this is the most important rationale for using PPML.

It is important to notice that this paper is not the first to address either zero trade flows or both zeros and heteroscedastic residuals in the GATT/WTO empirical literature. On the one hand, several articles estimate the GATT/WTO effect on trade taking into account zeros without dealing with the problem of heroskedasticity. The two earliest papers in this group look at the GATT/WTO issue in a peripheral way. The first one, Felbermayr and Kohler (2006), relies on the Tobit model to incorporate zero trade flows. The second paper (Helpman et al. 2008) accounts for non-observable firm heterogeneity in a framework that also considers an extensive country-level margin of trade, running a Heckman-type procedure for empirical estimation. This second approach is also used, as a robustness check, by Dutt et al. (2013) in their work on the effect of WTO on the extensive and intensive product margins of trade. It is worth pointing out that both methods hinge crucially on the assumption of homoskedasticity.[10] Other articles that focused particularly on the case study of GATT/WTO address the problem of zeros with alternative approaches that are also subject to criticism. Roy (2011) includes zero trade observations by adding a small positive constant to all import flows to allow for log-linearization of zero trade flows.[11]Analogously, Kohl and Trojanowska (2015), include zero trade flows, by recoding them from 0 to 1.[12] Finally, Kohl (2015) incorporates zero trade flows using (zero-inflated) negative binomial maximum likelihood estimation, a method that has been criticized because it depends on the unit of measurement of the dependent variable (Head and Mayer 2014, p. 174).

On the other hand, some articles both account for zeros and also allow for heteroskedastic residuals using a Poisson estimator. The first paper that estimates the GATT effect on trade dealing with both problems at once is Liu (2009). Felbermayr and Kohler (2010), Herz and Wagner (2011), Bista (2015) and Gil-Pareja et al. (2016) have subsequently pursued the Poisson approach. However, none of them includes country-pair fixed effects and country-year fixed effects in the gravity equation simultaneously due to convergence issues or because the large number of fixed effects precludes it.[13]

9 Obviously, the gravity equation in its log-linear specification is not defined for zero trade flows. This problem results in a sample selection bias that can be particularly important in datasets with a large number of trade observations that are zero in levels.

10 Tobit and Heckman-type procedures can deal with zero trade relationships but they are not robust to misspecification of the error term (Felbermayr and Kohler 2010).

11 Santos Silva and Tenreyro (2006) show that this approach leads to inconsistent parameter estimates.

12 It is worth noting that these authors provide an interesting contribution to the literature by accounting for countries' participation in the GATT/WTO (as in Tomz et al. 2007) with matching techniques.

13 Larch et al. (2019) provides a list of papers on other areas of research that are unable to obtain estimates with a full set of fixed effects with PPML.

Hence, this paper contributes to this literature by estimating the following gravity equation using PPML:

$$X_{ijt} = \exp(\beta_1 RTA_{ijt} + \beta_2 CU_{ijt} + \beta_3 GATT/WTO_{ijt} + \chi_{it} + \lambda_{jt} + \eta_{ij}) + u_{ijt} \quad (1)$$

where i denotes the exporter, j denotes the importer and t is time. The dependent variable is the value of bilateral trade flows (in levels) from country i to country j, and the set of independent variables includes binary dummy variables for common membership in regional trade agreements (*RTA*), currency unions (*CU*) and *GATT/WTO* (our variable of interest), as well as exporter-time fixed effects (χ_{it}), importer-time fixed effects (λ_{jt}) and country-pair fixed effects (η_{ij}).[14] Finally, u_{ijt} denotes the error term.

Furthermore, we carry out some robustness checks by examining the impact of GATT/WTO across periods and groups of countries by splitting the variable of interest in gravity Eq. (1) accordingly.

3 Data

This paper uses the Glick and Rose (2016) dataset and extends it by including the GATT/WTO dummy variables.[15] The data comprise annual bilateral trade flows between more than 200 IMF country codes over the period 1948–2013 (with gaps).[16] The dependent variable (unidirectional bilateral trade flows in US dollars) comes from *Direction of Trade* dataset assembled by the International Monetary Fund. We use three alternative measures for the dependent variable that are available in the dataset (exports from country i to country j, imports by country j from country i, and the average of imports and exports). Data on GDPs come from *World Development Indicators*, supplemented where necessary by *Penn World Table* Mark 7.1 and IMS's *International Financial Statistics*. The data for latitude and longitude, landlocked and island status, physically contiguous neighbors, language and colonizers have been obtained from CIA's *World Factbook*. Currency Union data rely on the IMF's *Schedule of Par Values* and issues of the IMF's *Annual Report on Exchange Rates Arrangements and Exchange Restrictions*, supplemented with information from the *Statesman's Yearbook*. Following Glick and Rose (2016), we use a transitive definition of currency union. That is, if dyads *x*–*y*, and *x*–*z* are in currency unions, then *y*–*z* is also in a currency union. Data on regional trade agreements are taken from the World Trade Organization's website. We also resort to this website to

[14] It is worth noting that the reference category for the economic integration agreements dummy variables (*RTA*, *CU* and *GATT/WTO*) includes both pairs of non-member countries and member-non-member pairs avoiding the concern about multicollinearity raised by Cheong et al. (2014). Section 5 confirms the robustness of the results to changes in the reference category.

[15] We gratefully acknowledge Andrew Rose for making his data publicly available.

[16] It is noteworthy that not all areas covered are countries in the conventional sense of the word. The dataset also includes some colonies (e.g. Gibraltar), territories (e.g. Guam) and overseas departments (e.g. Guadeloupe).

obtain the date of accession of each country to the multilateral trade system that is used to create the dummy variables for GATT/WTO membership.

4 Empirical results

Before turning to the discussion of the results, it is worth noting that in this section we primarily use data at five-year-intervals rather than data pooled over consecutive years. This choice is based on the argument raised by Trefler (2004), among others. This author criticizes trade estimations using data pooled over consecutive years because it is reasonable to expect that the adjustment of trade flows in response to trade policy changes will not be instantaneous. Moreover, as Chen and Wall (2005) point out, the issue of time required to adjustment is even more pronounced in econometric specifications with fixed effects such as those used in this paper. Olivero and Yotov (2012) provide empirical evidence that gravity estimates obtained with three-year and five-year interval trade data are very similar, whereas estimations performed with panel data samples pooled over consecutive years lead to suspicious estimates of the trade cost elasticity parameters. In order to overcome this criticism, we follow previous work and use panel data at intervals.[17] In the sensitivity analysis section, we carry out some robustness checks using data for consecutive years.

As a benchmark, Table 1 presents the results from three estimators that have been widely employed in previous studies on the effect of GATT/WTO on trade, which do not simultaneously account for all sources of estimation bias discussed above. The first one is the OLS estimator with time-varying exporter and importer fixed effects as well as time-invariant country-pair fixed effects. The second one is the (country pair) Fixed-Effect Poisson maximum-likelihood estimator. The third one is the PPML estimator with time-varying directional (source and destination) country-specific dummies. In order to check the consistency of the results with the use of alternative dependent variables Table 1 reports our findings for imports by *j* from *i*, exports from *i* to *j* and the average of imports and exports.

The first three columns of Table 1 depict the results for the log-linear version of the gravity equation with OLS. The estimated coefficients for regional trade agreements (*RTA*), currency unions (*Currency union*) and the GATT/WTO (*Both in GATT/WTO*) are positive and statistically significant at conventional levels, independently of the dependent variable employed. In particular, the point estimate for the *GATT/WTO* variable ranges from 0.149 to 0.162, implying that GATT/WTO entry expands trade between 16.1 percent [$\exp(0.149)-1=0.161$] and 17.6 percent

[17] Similarly to us, Chen and Wall (2005), Baier and Bergstrand (2007), Subramanian and Wei (2007), Vicard (2009), Eicher and Henn (2011), Behar and Cirera-i-Crivillé (2013), Kohl (2014) and Limão (2016) use of data at five-year intervals. Alternatively, Trefler (2004) uses three-year intervals, whereas Dai et al. (2014), Bergstrand et al. (2015), Anderson and Yotov (2016), and Gil-Pareja et al. (2016) use intervals of four years. We have also considered these alternative frequencies for the data (three-year and four-year intervals) and that hardly affects the estimates. These results are available from the authors upon request.

Table 1 Effect of GATT/WTO on bilateral trade (OLS and Poisson estimates)

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			Poisson Pseudo-Maximum Likelihood (PPML)			Poisson Pseudo-Maximum Likelihood (PPML)		
	Imports	Exports	Avg imp-exp	Imports	Exports	Avg imp-exp	Imports	Exports	Avg imp-exp
Both in GATT/WTO	0.151 (0.038)***	0.162 (0.040)***	0.149 (0.035)***	0.280 (0.054)***	0.224 (0.052)***	0.258 (0.051)***	0.480 (0 .103)***	0.365 (0.103)***	0.438 (0.100)***
RTA	0.417 (0.028)***	0.399 (0.028)***	0.426 (0.027)***	0.270 (0.054)***	0.309 (0.045)***	0.288 (0.047)***	0.497 (0.046)***	0.578 (0.044)***	0.530 (0.043)***
Currency union	0.521 (0.059)***	0.417 (0.057)***	0.441 (0.057)***	0.388 (0.041)***	0.344 (0.040)***	0.368 (0.039)***	−0.070 (0.069)	−0.147 (0.074)**	−0.103 (0.069)
Log GDP exporter				0.978 (0.075)***	1.050 (0.059)***	1.013 (0.064)***			
Log GDP importer				0.865 (0.053)***	0.746 (0.052)***	0.808 (0.050)***			
Log distance							−0.767 (0.030)***	−0.784 (0.029)***	−0.778 (0.029)***
Land border							0.284 (0.063)***	0.356 (0.064)***	0.325 (0.062)***
Common language							0.075 (0.056)	0.085 (0.056)	0.074 (0.055)
Ever in a colonial relationship							0.614 (0.084)***	0.571 (0.092)***	0.605 (0.088)***
Common country							1.782 (0.301)***	1.682 (0.271)***	1.699 (0.279)***
Number of islands							−0.054 (0.195)	−0.083 (0.200)	−0.189 (0.187)
Number landlocked							−0.951 (0.123)***	−1.000 (0.116)***	−0.953 (0.114)***

Table 1 (continued)

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			Poisson Pseudo-Maximum Likelihood (PPML)			Poisson Pseudo-Maximum Likelihood (PPML)		
	Imports	Exports	Avg imp-exp	Imports	Exports	Avg imp-exp	Imports	Exports	Avg imp-exp
Year dummies	No	No	No	Yes	Yes	Yes	No	No	No
CYFE	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
N. Observations	159,053	152,406	183,319	135,284	130,671	152,253	162,408	155,951	186,800
R-squared	0.876	0.871	0.867						

The regresand in columns (1)–(3) are the log of bilateral imports j from i, exports i to j and the average value of exports and imports, measured by dyad-year

The regresand in columns (4)–(9) is the value of bilateral imports j from i, exports i to j and the average value of exports and imports, measured by dyad-year

Robust standard errors, clustered by dyad are in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$

CYFE stands for exporter-year and importer-year fixed effects. CPFE stands for country-pair fixed effects. Fixed effects are not reported for brevity

Five-year interval data on more than 200 countries over the period 1948–2013 [exp(0.162) − 1 = 0.176]. However, it is worth pointing out that this estimator does not allow tackling the issues related to heteroskedasticity and zeros.

Columns (4) to (6) provide the results using the Poisson estimator with country-pair fixed effects, which allow accounting for unobserved bilateral heterogeneity. Yet, this estimator does not control for multilateral resistance since it does not include exporter-time and importer-time fixed effects. In this specification, we include the logarithm of the importer and exporter GDP, as well as year dummies to capture common shocks and trends across countries. The estimated coefficients for the GDPs are in line with those reported in previous studies. Similarly to the results in columns (1) to (3), the point estimates of the three economic integration agreements are positive and highly statistically significant. In particular, the point estimates for the GATT/WTO are somewhat higher and fall within an interval that ranges from 0.224 to 0.280 when using exports and imports as the dependent variable, respectively.

Finally, columns (7) to (9) present the results using the PPML estimator including exporter-time and importer-time fixed effects to account for multilateral resistance terms. These specifications do not include country-pair fixed effects in order to account for both endogeneity and unobserved bilateral heterogeneity. Yet, they incorporate bilateral time invariant trade supporting or impeding measures, such as the logarithm of bilateral distance (*Log distance*), and dummy variables for adjacency (*Land border*), the use of a common language (*Common language*), the existence of colonial ties (*Ever in a colonial relationship*), and being a common country in the past (*Common country*). Furthermore, two variables that indicate the number of countries in the pair that are islands (*Number of islands*) and landlocked (*Number of landlocked*) are included. Overall, the results for the time-invariant controls are economically meaningful in sign and size and highly statistically significant. With regard to the estimated coefficients for the economic integration agreements, again the dummies for both regional trade agreements and GATT/WTO have point estimates that are positive and statistically significant at the 1 percent level of significance, in a range that goes from 0.365 to 0.480 in the case of GATT/WTO. In these specifications the currency union dummy presents a counterintuitive sign, although in two of the three cases the estimated coefficient is not statistically significant. Anyway, it is worth pointing out that unobserved bilateral heterogeneity and the likely endogeneity of economic integration agreements may be biasing the coefficient estimates (upwards or downwards).

The results in Table 1 confirm the existence of a positive GATT/WTO effect on trade in line with the findings in most of the subsequent work to Rose's (2004) seminal contribution. However, as previously discussed, all these estimations may yield biased results since they do not account simultaneously for the previously discussed sources of bias in a single regression. In order to comprehensively handle all the previous concerns, we estimate the gravity Eq. (1) using PPML including exporter- and importer-time fixed effects as well as country-pair time-invariant fixed effects, which is our preferred specification. The results for the three alternative measures of the dependent variable are displayed in columns (1) to (3) of Table 2. The point estimates for regional trade agreements and currency unions are always positive and statistically significant at the 1 percent level. However, and very importantly, we find

Table 2 Effect of GATT/WTO on bilateral trade (PPML estimates)

Specification	(1) Imports	(2) Exports	(3) Avg imp-exp	(4) Imports	(5) Imports	(6) Imports	(7) Imports	(8) Imports
Both in GATT/WTO	−0.027 (0.080)	−0.042 (0.077)	−0.002 (0.075)					
RTA	0.137 (0.041)***	0.183 (0.035)***	0.157 (0.038)***	0.138 (0.040)***	0.135 (0.040)***	0.136 (0.040)***	0.138 (0.039)***	0.137 (0.041)***
Currency union	0.169 (0.048)***	0.133 (0.043)***	0.165 (0.044)***	0.164 (0.049)***	0.165 (0.048)***	0.164 (0.048)***	0.171 (0.048)***	0.167 (0.048)***
Both in GATT/WTO, by country type								
One early, one late				0.003 (0.086)				
Both late joiners				−0.130 (0.074)*				
Both industrial countries					0.037 (0.119)	0.034 (0.119)		
No industrial countries					0.052 (0.106)	0.053 (0.106)		
Industrial, nonindustrial country					−0.027 (0.082)			
Exporter industrial, importer nonindustrial						−0.085 (0.079)		
Exporter nonindustrial, importer industrial						0.016 (0.113)		
By importer characteristics								
Industrial country							−0.042 (0.105)	
Nonindustrial country, old member							−0.107 (0.081)	

Table 2 (continued)

Specification	(1) Imports	(2) Exports	(3) Avg imp-exp	(4) Imports	(5) Imports	(6) Imports	(7) Imports	(8) Imports
Nonindustrial country, new joiner							0.095 (0.112)	
By exporter characteristics								
Industrial country								−0.104 (0.091)
Nonindustrial country, old member								−0.004 (0.123)
Nonindustrial country, new joiner								0.082 (0.071)
CYFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	159,053	152,406	183,319	159,053	159,053	159,053	159,053	159,053

The regresand in columns (1)–(3) are the bilateral imports j from i, exports i to j and the average value of exports and imports, measured by dyad-year

The regresand in columns (4)–(8) is the value of bilateral imports j from i, measured by dyad-year

Robust standard errors, clustered by dyad are in parentheses. $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$

CYFE stands for exporter-year and importer-year fixed effects. CPFE stands for country-pair fixed effects

Fixed effects estimates are not reported for brevity. Five-year interval data on more than 200 countries over the period 1948–2013

One early, one late is a binary variable that takes value one if one country of the dyad was a member in 1948 (early joiner) and the other joined afterwards

Both late joiners is a binary variable that equals one for pairs that joined GATT after 1948, and zero otherwise that the impact of GATT/WTO vanishes once we include the full set of fixed effects in the PPML estimator.[18]

In columns (4)–(8) of Table 2, we further explore the GATT/WTO effect on trade through the examination of its impact for different groups of countries. For brevity, henceforth we only report the results using imports as the dependent variable, which follows the common practice in this literature. Nevertheless, we will point out in the text any difference worth mentioning with the alternative measures (exports and exports-imports average). Column (4) presents the results when we distinguish between early joiners (those countries that adhered to the GATT in the year of entry into force) and late joiners (those that joined the multilateral agreement in 1949 or later). To this end, we split the GATT/WTO dummy into two dummies: one for pairs of countries that joined the GATT after 1948 (*Both late joiners*); and one for pairs including both kinds of countries (*One early, one late*).[19] Interestingly, the results show no GATT/WTO trade effects again.

Next, we investigate the effect of GATT/WTO across groups of countries with a standard classification criterion in this literature (industrialized versus developing countries –nonindustrial countries-).[20] In column (5), we disaggregate the GATT/WTO dummy into three dummies: one for industrialized country members (*Both industrial countries*); another for nonindustrial country members (*No industrial countries*) and the third one for pairs combining industrial and nonindustrial country members (*Industrial, nonindustrial county*). Column (6) maintains the previous first two groups and further disaggregates the dummy for trade between industrial and nonindustrial members taking into account the direction of the export flows between them. The results of columns (5) and (6) unequivocally reveal the absence of a positive GATT/WTO trade effect.

The last two columns of Table 2 report the results when using a classification of countries that allows us investigating whether the change in the terms of accession for new entrants after the Uruguay Round (i.e., the obligation of a greater liberalization commitment for "new" developing countries that join the WTO since its creation than for the "old" developing countries that joined the GATT) has had an effect in the variable of interest. To this end, following Subramanian and Wei

[18] Rose's dataset includes only positive trade flows. However, as a robustness check, we have also estimated the gravity equations treating all missing observations as zero trade flows (in line with Felbermayr and Kohler 2006; Helpman et al. 2008; or, more recently, Larch et al. 2019). The results of these estimations are qualitatively and quantitatively very similar to those reported in columns (1)–(3) of Table 2. For brevity, the results with zeros are not reported, but are available from the authors upon request. Furthermore, in the sensitivity analysis section, we have estimated model (1) using other datasets that include zero trade flows, such as those in Limão (2016), Head and Mayer (2013), and Gil-Pareja et al. (2016) and the results confirm the absence of the GATT/WTO effect on trade.

[19] It is worth noting that, since trade data is available from 1948, the GATT trade effects between the 23 countries that joined the GATT in that year cannot be estimated because they are absorbed by the country-pair fixed effects.

[20] Several papers have addressed the GATT/WTO effect on trade distinguishing between industrial and developing countries with remarkably mixed results (Subramanian and Wei 2007; Felbermayr and Kohler 2010; Eicher and Henn 2011; Dutt et al. 2013; Kohl 2015; Bista 2015; Gil-Pareja et al. 2016). However, only do the last two papers take into account the group that each country in the pair belongs to (as we do here).

(2007), with cross-section data, and Gil-Pareja et al. (2016), with panel data for the period 1960–2008, we split nonindustrial countries into two groups: those that were members before 1995 ("*old members*"); and those that become members since 1995 ("*new members*"). The results in column (7) disaggregate the GATT/WTO dummy into three dummies by importer characteristics: "*industrial country*"; "*nonindustrial country, old member*"; and, "*nonindustrial country, new joiner*". The results in column (8) provide the equivalent classification using the exporter characteristics. Again, the results reinforce our previous findings regarding the absence of GATT/WTO effects on bilateral trade flows in all groups.

In order to dig deeper into the impact of GATT/WTO on trade we further carry out the analysis by periods using two alternative classification criteria. First, we restrict the sample period by rounds of trade negotiations (in a cumulative way). Second, we split the 66 years of sample period into six sub-periods with the same number of years. To this end, in Table 3 we use data for consecutive years (instead of data at five-year intervals) to guarantee the inclusion of the first and the last year of each period. The results when we confine the sample by rounds of trade negotiations are reported in Panel A of Table 3. The first period considered goes from 1948 to Dillon round (1961), the second one up to Kennedy round (1967), the third one up to Tokyo round (1979) and the fourth one up to Uruguay round (1994). It is remarkable that the estimated coefficient of GATT/WTO dummy is never positive. Indeed, it is even negative and statistically significant (at least at the 10 percent level of significance) in three of the four cases.[21] Second, panel B of Table 3 reports the results when we split the 66 years of sample period into six sub-periods of the same length (i.e. eleven years).[22] The results provide support to our previous findings. In particular, the estimated coefficients on the impact of GATT membership are negative and statistically significant at conventional significance levels for three periods (1948–1958, 1959–1969 and 1981–1991), positive but statistically non-significant in one period (1992–2002), and positive and statistically significant at 10 percent level for the 1970s, while positive and statistically significant at 1 percent over 2003–2013. However, the results of the previous two positive effects are not robust when we use exports from country i to country j instead of imports by j from i as the dependent variable. The positive effect vanishes while the rest of results reported in the table do remain unaltered.

So far, in all the specifications we have only considered the contemporaneous values of the variables for common membership in regional trade agreements, currency unions and GATT/WTO. However, as Baier and Bergstrand (2007) pointed out, many agreements are "phased-in" over time (typically over 10 to 15 years), and terms-of-trade changes tend to have lagged effects on trade volumes. In order to account for these effects, we estimate the model in column (1)

[21] This result is in line with Felbermayr and Kohler (2010), who show negative effects for the three time-spans considered over the GATT period (1948–1994).

[22] This classification criterion follows Rose (2004) and Eicher and Henn (2011) that split their sample periods by decades. We have further split the sample period using different classification criteria and the results remain quantitatively and qualitatively unchanged. The results are available upon request.

Table 3 GATT/WTO effects by sub-periods (PPML estimates)

Specification	Panel A. By GATT round (accumulated)				Panel B. By 11-year periods					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1948–1961	1948–1967	1948–1979	1948–1994	1948–1958	1959–1969	1970–1980	1981–1991	1992–2002	2003–2013
Both in GATT/WTO	−0.172 (0.066)***	−0.148 (0.054)***	−0.035 (0.053)	−0.119 (0.071)*	−0.183 (0.063)***	−0.094 (0.047)**	0.129 (0.072)*	−0.383 (0.129)***	0.082 (0.057)	0.145 (0.052)***
RTA	0.117 (0.032)***	0.301 (0.040)***	0.341 (0.043)***	0.386 (0.043)***	−0.010 (0.041)	0.342 (0.052)***	0.296 (0.040)***	0.130 (0.045)***	0.016 (0.022)	0.041 (0.023)*
Currency union	0.105 (0.086)	0.153 (0.088)*	0.762 (0.127)***	0.808 (0.109)***	0.098 (0.200)	0.175 (0.051)***	0.335 (0.091)***	−0.223 (0.070)***	−0.030 (0.028)	−0.022 (0.049)
CYFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	49,935	84,075	190,746	374,820	36,654	60,171	101,349	127,991	192,290	234,360

The regresand is the value of bilateral imports, measured by dyad-year

Robust standard errors, clustered by dyad are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

CYFE stands for exporter-year and importer-year fixed effects. CPFE stands for country-pair fixed effects

Fixed effects estimates are not reported for brevity. Annual data for consecutive years on more than 200 countries over the period 1948–2013

Table 4 Effect of GATT/WTO with lags and one lead (PPML estimates)

Specification	(1) 1 lag	(2) 2 lags	(3) 3 lags	(4) 1 lead	(5) 1 lag 1 lead	(6) 2 lags 1 lead	(7) 3 lags 1 lead
Both in GATT/WTO	0.078 (0.109)	0.189 (0.133)	0.245 (0.157)	−0.098 (0.081)	0.036 (0.104)	0.141 (0.124)	0.195 (0.146)
Both in GATT/WTO (1 lead)				0.074 (0.074)	0.074 (0.077)	0.120 (0.080)	0.149 (0.084)*
RTA	0.187 (0.051)***	0.212 (0.056)***	0.259 (0.051)***	0.165 (0.035)***	0.226 (0.046)***	0.310 (0.046)***	0.346 (0.049)***
RTA (1 lead)				0.021 (0.029)	0.019 (0.028)	0.026 (0.025)	0.023 (0.026)
Currency union	0.183 (0.053)***	0.227 (0.061)***	0.548 (0.099)***	0.209 (0.040)***	0.253 (0.048)***	0.646 (0.102)***	0.682 (0.114)***
Currency union (1 lead)				−0.043 (0.043)	−0.49 (0.048)***	−0.047 (0.039)	−0.074 (0.039)*
CYFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	156,090	152,682	148,611	136,143	133,180	129,772	125,702

The regresand is the value of bilateral imports, measured by dyad-year. Robust standard errors, clustered by dyad are in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$. Reported coefficients in columns (1)–(3) and (5)–(7) of the variables Both in GATT/WTO, RTA and Currency Union include the contemporaneous and the lagged effects. CYFE stands for exporter-year and importer-year fixed effects. CPFE stands for country-pair fixed effects. Fixed effects estimates are not reported for brevity. Five-year interval data on more than 200 countries over the period 1948–2013 of Table 2 including lags of the dummy variables *RTA, Currency Union* and *Both in GATT/WTO*. Columns (1) to (3) of Table 4 report the results when adding one, two and three lags for these variables, respectively. In order to see more easily the cumulative impact of the inclusion of lags, in these specifications we report the sum of the estimated coefficients from contemporaneous and lagged effects. We find that regional trade agreements have positive and statistically significant overall effects, and the inclusion of lags increases its point estimate from 0.137 in the specification without lags (column 1 of Table 2) to 0.187 (with one lag), 0.212 (with two lags) and 0.259 (with three lags). A similar pattern emerges for currency unions. In this case, the point estimates rise from 0.169, considering only the current effect, to 0.548 incorporating three lags of the variable in the regression. In both cases, the coefficient estimates have economically meaningful values. With regard to our variable of interest the point estimates of the impact of GATT membership also increase with the inclusion of lags, but the estimated coefficient for the cumulative effect remain statistically non-significant at conventional levels in all cases.

Moreover, columns (4) to (7) of Table 4 display the results when we further add one lead to the following four alternative specifications: without lags; with one lag; with two lags; and with three lags. This allows us testing for strict exogeneity of economic integration agreements (Wooldridge 2010). The regressions pass the test of strict exogeneity. In addition, similarly to the results in columns (1)–(3) of this Table, we find that, the point estimates for regional trade agreements and currency unions are statistically significant and continuously rise as we increase the number of lags from no lags (column 4) to three lags (column 7). This is also true for the *GATT/WTO* variable, but again it does not reach the statistical significance at conventional levels in any case.

Next, in Table 5 we further check for the consistency of our main result about the lack of a positive effect of GATT/WTO on trade. In particular, we test whether this finding still holds when we exclude from the regressions either the dummy variable for regional trade agreements, the dummy for currency unions or we exclude both at once. Before presenting the results, it should be stressed that a model that deletes one or more variables that are significant risks omission bias and inconsistency of the regression coefficients for the remaining economic integration agreements. However, this exercise is interesting here because all our previous results remain unaltered. For comparison purposes, column (1) of Table 5 replicates the results in column (1) of Table 2, our preferred specification. In that model, we include dummies for the three types of economic integration agreements *(RTA*, *Currency Union*, and *Both in GATT/WTO*). Column (2) presents the results when we exclude from the specification the dummy for *RTA*. Regression in column (3) excludes the dummy for *Currency Union*, whereas regression in column (4) excludes both. As we can see, the point estimate of the variable of interest hardly varies in a range that goes from −0.027 in the full specification to −0.053 in the specification that only includes the *Both in* GATT/WTO dummy, and interestingly they are not statistically significant in any case. Moreover, the estimated coefficients for *RTA* and *Currency Union* remain unaltered, even when we exclude the GATT/WTO dummy variable from the specification (columns 5 and 6).

Up to now, the results in this section clearly point out towards the absence of a positive GATT/WTO effect when estimating the gravity equation with PPML including the full set of fixed effects (exporter-year, importer-year and country pair) that currently constitute the "state of the art" in the empirical literature. As previously discussed, recent computational advances in the estimation with PPML have made feasible this method of estimation in large datasets that requires the computation of a huge set of fixed effects.

It is nowadays quite well documented in the literature that PPML estimates often reduce gravity estimates (Santos Silva and Tenreyro 2010b; Head et al. 2010; Eaton et al. 2013; Head and Mayer 2013, 2014; Mayer et al. 2018; Larch et al. 2019). In fact, our results show that switching from OLS (columns 1 to 3 of Table 1) to PPML (columns 1 to 3 of Table 2) leads to a fall in the point estimates for all three trade-policy variables to the extent that the GATT/WTO effect disappears. A plausible explanation, provided by Head and Mayer (2014), is that this comes from an underlying heterogeneity in effects, combined with the fact that the PPML estimator put more weight on pairs of countries with large expected levels of trade.

Following Mayer et al. (2018), in order to verify whether the effect of GATT/WTO is smaller for large predicted flows resulting in smaller overall effects, we first estimate a weighted (with weights proportional to levels of trade flows) log-linear specification and, secondly, we run PPML on trade shares. To facilitate the comparison with our previous results, the first two columns of Table 6 replicate the results reported in column (1) of Table 1 (OLS with the three types of high dimensional fixed effects) and column (1) of Table 2 (our preferred specification, which is comparable to the OLS estimation). The weighted OLS estimates (column 3) are quite close to those found with the PPML estimator (column 2). Besides, we confirm this pattern in columns (4) and (5), which reports PPML on trade shares (bilateral imports divided by total imports and bilateral imports divided by the importer's GDP, respectively) rather than trade flows. Intuitively, this specification should also give less weight to large bilateral trade flows in levels since it works in shares. Comparing these two columns with column (1), we clearly see that the point estimates are, indeed, rather similar. Therefore, log-linear OLS and PPML estimates may lead to quite different conclusions, which in line with Mayer et al. (2018) findings. As these authors point out, this is mainly due to how those estimators weight dyads with large predicted flows, which generally seem to have lower trade elasticities.[23]

5 Sensitivity analysis

This section carries out a number of robustness checks on our previous findings. In particular, we test whether the results are robust to (i) the use of data for consecutive years, (ii) the inclusion of an indicator to capture the GATT/WTO effect when only

[23] Novy (2013) and Bas et al. (2017) provide two different theoretical models featuring this type of heterogeneous elasticities. They argue that the effect of trade costs on trade flows varies depending on how intensely two countries trade with each other.

Table 5 GATT/WTO effects using different trade policy variables

Specification	(1)	(2)	(3)	(4)	(5)	(6)
Both in GATT/WTO	−0.027 (0.080)	−0.040 (0.080)	−0.040 (0.081)	−0.053 (0.081)		
RTA	0.137 (0.041)***		0.137 (0.041)***		0.137 (0.041)***	
Currency union	0.169 (0.048)***	0.168 (0.048)***				0.169 (0.048)***
CYFE	Yes	Yes	Yes	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	159,053	159,053	159,053	159,053	159,053	159,053

The regresand is the value of bilateral imports, measured by dyad-year

Robust standard errors, clustered by dyad are in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$

CYFE stands for exporter-year and importer-year fixed effects. CPFE stands for country-pair fixed effects

Fixed effects estimates are not reported for brevity

Five-year interval data on more than 200 countries over the period 1948–2013

the importer is a GATT/WTO member, (iii) the consideration of nonmember participants *à la* Tomz et al. (2007), and (iv) the use of alternative datasets.

5.1 Annual data for consecutive years

Previous section uses data at five-year intervals since trade estimations pooled over consecutive years are criticized on the grounds that the adjustment of trade flows to trade policy changes cannot fully adjust in a single year's time (Trefler 2004; Chen and Wall 2005, among others). In order to check whether the main results remain unaltered when we use data pooled over consecutive years, we have re-estimated all previous specifications using PPML under this data scheme. The results do not change in any significant way. To save on space, we do not report these results in the paper, but they are available from the authors upon request.

5.2 Both in GATT/WTO and Only importer in GATT/WTO

Until now, we have captured the GATT/WTO effect on trade including only a *Both in GATT/WTO* indicator variable (*bothwto*) in the gravity equation (a dummy that equals 1 when both countries in a pair are GATT/WTO members, and zero otherwise). Hence, the reference category comprises both when no country of the dyad is nonmember, as well as the cases in which only one country is a member.

The specification including only the *Both in the GATT/WTO* dummy variable may suffer from an omitted variable bias in the estimation of the impact of GATT/WTO on trade if GATT/WTO members do change their trade policy against nonmembers. When a country *j* becomes a GATT/WTO member, the country must apply trade liberalization by the most-favoured-nation principle to all other members. Thus, we

Table 6 GATT/WTO effect. Weighted OLS, PPML with trade shares

	(1) OLS [Table 1, col (1)]	(2) PPML (imports > 0) [Table 2, col 1)]	(3) OLS Weighted	(4) PPML [share -imports-]	(5) PPML [share -GDP-]
Both in GATT	0.151 (0.038)***	−0.027 (0.080)	0.107 (0.058)*	0.136 (0.043)***	0.109 (0.058)*
RTA	0.417 (0.028)***	0.137 (0.041)***	0.138 (0.037)***	0.239 (0.026)***	0.155 (0.036)***
Currency union	0.521 (0.059)***	0.169 (0.048)***	0.110 (0.041)***	0.449 (0.052)***	0.262 (0.061)***
CYFE	Yes	Yes	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes
N. Observations	159,053	159,053	159,053	159,053	146,768

The regresands in columns (1) and (3) are the ln of value of bilateral imports, measured by dyad-year

The regresand in columns (2) is the value of bilateral imports, and the regresands in columns (4) and (5) are trade shares (bilateral imports divided by total imports and by the importer's GDP, respectively). Robust standard errors, clustered by dyad are in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. CPFE stands for country-pair fixed effects. CYFE stands for exporter and importer year fixed effects

Five-year interval data on more than 200 countries over the period 1948–2013

would expect the effect of *bothwto* to be positive on bilateral trade flows. In addition, there may be an additional positive effect on trade when GATT/WTO members (while not obligated) extend the tariff reduction and other liberalization measures to nonmembers. We use a dummy variable *Only importer in GATT/WTO* (*imwto*, hereafter) that takes value 1 if only the importer is a GATT/WTO member, and zero otherwise, in order to capture this potential positive effect. If that were the case, the effect of *imwto* would be positive with respect to nonmember pairs and omitting the *imwto* indicator variable in the gravity equation would bias downward the estimate of *Both in GATT/WTO* variable.[24]

However, the simultaneous inclusion of *bothwto* and *imwto* in the gravity equation poses a methodological challenge due to the multicollinearity problem that arises between the two indicator variables and the importer-year fixed effects (included in the regression to control for multilateral resistance terms), as showed by Cheong et al. (2014). The inclusion of the full set of importer-year fixed effects makes it impossible to estimate both variables simultaneously. Indeed, the terms of multilateral resistance are considered one of the most crucial factors that must be accounted for in order to avoid the omitted variable bias in the estimation of gravity equations of international trade. Therefore, we face the following trade-off: on one hand, the inclusion of both variables (*Both in GATT/WTO* and *Only importer in GATT/WTO*) precludes the estimation of the full set of exporter- and importer-year

[24] The authors gratefully acknowledge one of the referees for this discussion and the suggestion to include the *imwto* indicator in the list of controls.

fixed effects; on the other hand, the non-inclusion of the *imwto* indicator may bias downward the estimate of *Both in GATT/WTO* variable.

To address this issue, we begin by estimating the gravity equation without country-year fixed effects (using annual data for consecutive years) but including both exporter and importer GDPs as well as year fixed effects. Column (1) of Table 7 reports results from the estimation of the same model as in column (4) of Table 1, except for the periodicity of the data. The point estimate of *Both in GATT/WTO* (omitting the *imwto* indicator) is 0.194 with a standard error of 0.061. At first glance, we observe that this coefficient remains nearly unaltered (0.188) when we add the *imwto* indicator (column 2 of Table 7). Additionally, the point estimate of the *imwto* indicator is very close to zero and non-statistically significant at conventional levels. Hence, omitting the *imwto* indicator in this specification does not affect the estimated coefficient of *Both in GATT/WTO*. More interestingly, we confirm our previous results about the lack of a GATT/WTO effect when we include country-time dummies assuming that multilateral resistance terms do not vary yearly, but every five years, in order to be able to identify the *imwto* effect (columns 3 and 4). Once we account for multilateral resistance terms in this way, we consistently find that *Both in GATT/WTO* effect vanishes and the *imwt*o effect remains close to zero and non-statistically significant. These results are also confirmed if we alternatively assume that multilateral resistance terms vary every two years (column 5 and 6), which is the shortest period of time that we can keep them constant while still being able to identify the *imwto* effect.

5.3 GATT/WTO participation: colonies, de facto members and provisional members

Tomz et al. (2007) were the first authors to question the findings by Rose (2004). These authors (TGR, henceforth) showed that Rose had mistakenly classified a large number of countries as non-participants whom the agreement applied to. In particular, they argue that, in fact, these countries had rights and obligations under the agreement. TGR document that the GATT rules applied not only to formal members but also to three categories of nonmember participants: colonies and overseas territories, de facto members (newly independent states) and provisional members. Using the same data and methods as in Rose (2004), they find that "…the GATT substantially increased the trade of *both* formal members and nonmember participants, compared to countries outside the agreement". They even claim that "…the solution to the mystery lies in correctly classifying nonmember participants, who were bound by the agreements" (p. 2011). Therefore, the distinction between formal membership and informal participation seems to be important.

To deal with this issue, we have estimated model (1) using PPML estimator on TGR's dataset. The results are presented in Table 8. To facilitate comparison, columns (1) and (4) replicates TGR's results in columns (5) and (6) of their Table 2, which correspond to TGR's two specifications that include the largest set of controls (country-pair fixed effects and year fixed effects). Column (1) of Table 8 reports the results including indicators for whether the countries in each pair were nonmember

Table 7 Robustness checks (I). GATT/WTO effect: Both GATT members and importer GATT member (PPML estimates)

Specification	(1)	(2)	(3)	(4)	(5)	(6)
Both in GATT/WTO	0.194 (0.061)***	0.188 (0.079)**	−0.019 (0.047)	−0.006 (0.022)	−0.042 (0.057)	0.019 (0.017)
Only importer in GATT/WTO		−0.010 (0.105)		0.018 (0.056)		0.074 (0.059)
RTA	0.286 (0.061)***	0.286 (0.061)***	0.132 (0.038)***	0.132 (0.038)***	0.132 (0.041)***	0.132 (0.041)***
Currency union	0.373 (0.038)***	0.373 (0.038)***	0.088 (0.040)**	0.088 (0.040)**	0.098 (0.042)**	0.098 (0.042)**
Log GDP exporter	1.013 (0.080)***	1.012 (0.081)***	0.945 (0.051)***	0.945 (0.052)***	0.812 (0.045)***	0.811 (0.045)***
Log GDP importer	0.896 (0.053)***	0.897 (0.054)***	1.114 (0.051)***	1.113 (0.051)***	1.158 (0.048)***	1.157 (0.048)***
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
CYFE constant at intervals	No	No	5-YEAR	5-YEAR	2-YEAR	2-YEAR
CPFE	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	656,721	656,721	656,713	656,713	656,708	656,708

The regresand is the value of bilateral imports, measured by dyad-year. Robust standard errors, clustered by dyad are in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$. CPFE stands for country-pair fixed effects

CYFE constant at intervals stand exporter and importer time fixed effects at intervals of 5 and 2 years. Fixed effects are not reported for brevity. Annual data for consecutive years on more than 200 countries over the period 1948–2013

participants. They find significantly higher trade when both countries had GATT rights and obligations, either as formal members or as nonmember participants, and when only one participates in GATT, either formally or informally. Moreover, surprisingly (in TGR's own words), the effect for nonmember participants is larger than for formal members. However, when we estimate the same model using PPML estimator and assuming that multilateral resistance terms vary every five years (in order to allow us to estimate the effect when *only-one-country* of the dyad participates) the five variables of interest become non-significant at conventional levels whereas the point estimates for regional trade agreements and currency unions remain positive and economically and statistically significant (column 2). Column (3) shows that our results hold when we only account for GATT participation of both countries in the dyad (omitting the dummies that capture participation by only one country) and properly controlling for multilateral resistance by exporter-year and importer-year fixed effects.

Column (4) corresponds to column (6) of Table 2 in TGR where the authors reduce the number of parameters by imposing the restriction that formal membership has the same effect as nonmember participation. They find that trade is about 72 percent higher when both countries in the pair participate in the GATT, and 31 percent higher when one country participates in the GATT and the other does not. However, again, when we estimate model (1) using PPML estimator the effect of GATT/WTO participation vanishes. The estimated coefficients of both variables

Table 8 Robustness checks (II): GATT/WTO effects for member and nonmember participants

	(1) TGR Table 2, col. 5	(2)	(3)	(4) TGR Table 2, col. 6	(5)	(6)
Both participate in GATT				0.539 (0.060)***	−0.019 (0.072)	0.061 (0.084)
Both formal members	0.476 (0.062)***	0.009 (0.074)	0.041 (0.087)			
Formal member and non-member participant	0.565 (0.063)***	−0.008 (0.075)	0.143 (0.109)			
Both nonmember participants	0.877 (0.094)***	0.005 (0.116)	0.282 (0.198)			
Only one participates in GATT				0.266 (0.056)***	−0.038 (0.07)	
Formal member	0.229 (0.057)***	−0.012 (0.073)				
Nonmember participant	0.345 (0.067)***	−0.158 (0.100)				
GSP	0.182 (0.028)***	−0.021 −0.05	−0.022 (0.068)	0.19 (0.028)***	−0.022 (0.05)	−0.023 (0.068)
Log product real GDP	0.466 (0.048)***	0.517 (0.084)***		0.45 (0.047)***	0.521 (0.084)***	
Log product real GDP per capita	0.213 (0.046)***	0.325 (0.086)***		0.225 (0.046)***	0.322 (0.085)***	
Regional FTA	0.763 (0.072)***	0.427 (0.071)***	0.547 (0.069)***	0.769 (0.073)***	0.426 (0.071)***	0.547 (0.069)***
Currency union	0.608 (0.118)***	0.645 (0.111)***	0.680 (0.120)***	0.607 (0.117)***	0.645 (0.111)***	0.680 (0.120)***
Currently colonized	0.283 (0.159)*	0.551 (0.164)***	0.566 (0.181)***	0.309 (0.159)*	0.554 (0.164)***	0.568 (0.181)***
Year dummies	Yes	Yes	No	Yes	Yes	No
CYFE	No	No	Yes	No	No	Yes
CYFE constant at intervals	No	5-YEAR	No	No	5-YEAR	No
CPFE	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	234,597	233,731	233,475	234,597	233,731	233,475

The regresand is the value of bilateral imports, measured by dyad-year. Robust standard errors, clustered by dyad are in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$. CPFE stands for country-pair fixed effects. CYFE stands for exporter and and importer year fixed effects. CYFE constant at intervals stands for exporter and importer time fixed effects at intervals of 5 years. Fixed effects are not reported for brevity. Tomz et al. (2007) dataset

are very close to zero and not statistically significant at conventional levels. The results remain very similar when we only include the dummy variable *Both participate in GATT* (omitting *Only one participates in GATT*) and we use exporter-year and importer-year dummies to control for multilateral resistance (column 6).

In addition, following TGR (2007) we carry out PPML estimation allowing the effect of the GATT to vary over time from one negotiating round to the next (Table 3 of TGR) and for the various subsets of countries selected according their degree of industrialization, level of income, or geographic area (Table 4 of TGR). For the sake of brevity, we do not include these results in the paper, but we summarize the main findings.[25] In contrast with TGR's results, who find a positive and economically substantial effect of GATT participation in every round except for the last one, we find that the coefficient that captures the effect when both countries of the dyad participate in the GATT is never statistically significant at conventional levels. A similar result appears for the comparison between the coefficients corresponding to when only one participates. While they find a positive effect in six out of eight rounds, we find a positive association in only one of them. Finally, the comparison for the results across the twelve subsets of countries considered by TGR in their Table 4 exactly leads to the same conclusion. In this case, TGR find that benefits of GATT participation are not unique to countries at a certain level of development or to a particular region. In contrast, we find a positive effect only in one case when both countries participate in GATT/WTO, and no evidence of a positive effect when only one participates.

5.4 GATT/WTO effect using alternative datasets

So far, we have shown that the GATT/WTO effect on trade disappears when we estimate model (1) using PPML method simultaneously accounting for time-invariant unobservable bilateral heterogeneity and multilateral resistance. This result is extremely robust to using different measures of trade flows, alternative subsets of countries, different periods, to accounting for lagged effects, to excluding controls for regional trade agreements and/or currency unions, as well as to changes in the periodicity of the data, to controlling for the participation of only one country in GATT/WTO and to accounting for nonmember participants.

This sub-section carries out robustness checks in order to make sure that the absence of a positive effect is not driven by the particular dataset used in this paper. In this respect, the previous sub-section already tests this since we largely confirmed our results using Tomz et al. (2007) dataset. Furthermore, Table 9 presents the results when we estimate model (1) using PPML estimator on Limão (2016) dataset. This dataset covers the period 1965–2010 at five-year intervals. Column (1) replicates the results reported in column (5) of Table 2 in Limão (2016). Before discussing the results, it is worth noting that the specifications reported in Table 9 capture the long-run effects since they include both the contemporaneous effects and lagged effects (using lags of 5 and 10 years). As in Limão (2016), we provide the cumulative effect of the concurrent effect and the two lagged effects. Consistent with our previous findings, the results show a positive WTO effect using OLS with exporter-year, importer-year and country-pair fixed effects. However, when we use the PPML

[25] These results are available from the authors upon request.

estimator (with the three types of high dimensional fixed effects) the results clearly confirm that the WTO effect disappears both keeping the zeroes out of the regression (column 2) and maintaining them (column 3). Column (4) replicates column (6) of Table 2 of Limão (2016) in which he estimates the effects for four separate types of agreements: nonreciprocal preferential trade agreements (NR PTA), reciprocal preferential trade agreements (R PTA), free trade agreements (FTA) and a variable for customs unions, common markets and economic unions (CU/CM/EU). Again, we find that the positive and statistically significant effect for the WTO reported in column (4) using OLS, vanishes when we use the PPML estimator.[26]

6 Conclusions

Rose's (2004) seminal paper prompted an intense debate on the effect of GATT/WTO on bilateral trade flows. This author strikingly documented the absence of GATT/WTO effects on trade, but much of the subsequent work has concluded that GATT/WTO has had trade enhancing effects. The empirical work addressing this question has progressively improved the econometric specifications in order to account for potential sources of bias. However, computational issues have conditioned the choice of estimator. The large datasets used in the estimation of GATT/WTO effects and/or difficulties to achieve convergence have precluded accounting simultaneously for unobserved bilateral heterogeneity (with country-pair fixed effects), for multilateral resistance terms (with exporter-time and importer-time fixed effects), as well as for heteroskedastic residuals and zero trade flows (with PPML).

This paper re-examines this issue taking advantage of recent econometric developments that allow us estimating structural gravity equations with PPML on a large dataset requiring to compute three types of high-dimensional fixed effects: exporter-time, importer-time and country-pair fixed effects. Our results are clearly supportive to Rose's (2004) findings. That is, in contrast to the trade-enhancing effect of both regional trade agreements and currency unions, GATT/WTO does not seem to have encouraged trade. In particular, we show that in gravity estimations either using OLS with the full set of high-dimensional fixed effects or using PPML without all of them at once, the GATT/WTO effect on trade is positive. However, when we estimate the gravity equation with the full set of fixed effects, our results contrast with conventional wisdom and the vast majority of previous empirical results: GATT/WTO accession has not generated statistically significant positive trade effects. Moreover, the results hold using different measures of trade flows, across time periods and country groups using several alternative criteria of classification for both periods and groups of countries, and when we take into account the GATT/WTO accession dynamics. The results are also robust to changes in the periodicity of the data, to controlling for the participation of only

[26] We have also applied the *ppmlhdfe* Stata command to the datasets used by Head and Mayer (2013) and Gil-Pareja et al. (2016). In both datasets, the positive effect of the GATT/WTO obtained with OLS disappears when we use the PPML estimator (both excluding and including zeros).

Table 9 Robustness checks (III): GATT/WTO effect using Limão (2016) dataset

Specification	(1) OLS LIMAO	(2) PPML	(3) PPML	(4) OLS LIMAO	(5) PPML	(6) PPML
	Table 2, col. (5)	[Imports > 0]	[imports >=0]	Table 2, col. (6)	[imports > 0]	[Imports >=0]
PTA	0.599*** (0.050)	0.237*** (0.068)	0.206*** (0.067)			
NR PTA				−0.006 (−0.053)	−0.238*** (0.088)	−0.241*** (0.088)
R PTA				0.413*** −0.068	0.253*** (0.090)	0.205** (0.086)
FTA				0.533*** (0.062)	0.084 (0.081)	0.057 (0.081)
CU/CM/EU				1.160*** (0.091)	0.474*** (0.079)	0.460*** (0.079)
WTO	0.204*** (0.073)	0.230 (0.180)	0.107 (0.201)	0.242*** (0.073)	0.246 (0.162)	0.130 (0.183)
CYFE	Yes	Yes	Yes	Yes	Yes	Yes
CPFE	Yes	Yes	Yes	Yes	Yes	Yes
N. Observations	139,407	139,407	219,730	139,407	139,407	219,730

The regresand is the value of bilateral imports, measured by dyad-year. Robust standard errors, clustered by dyad are in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$. Reported coefficients of the variables *Both in GATT/WTO, RTA and Currency Union* in all the columns include the contemporaneous and the 2 lagged effects. CYFE stands for exporter-year and importer-year fixed effects

CPFE stands for country-pair fixed effects. Fixed effects estimates are not reported for brevity. In columns (1)–(3) PTA include Non-reciprocal PTA (NR PTA), Reciprocal PTA (R PTA), FTA or Custom Union (CU)/Common Market (CM)/Economic Union (EU)

one country in GATT/WTO and to accounting for nonmember participants *à la* Tomz et al. (2007), as well as to the use of alternative datasets. Importantly, these results are based on total trade flows, which put more weight on large bilateral trade flows. This may hide positive effects of GATT/WTO for small countries. In fact, when we estimate PPML on trade shares, we find a positive effect of GATT/WTO in line with that obtained with the log-linear OLS estimation with the full set of fixed effects. Therefore, the lack of GATT/WTO effect depends on the specification of the dependent variable. Future work should consider which dependent variable is the most appropriate for the research question.

In addition, our results do not deny the existence of some positive indirect effects of GATT/WTO on promoting trade, such as a generalized fall in trade barriers and more transparent, predictable and trade facilitating environment. These factors might have prompted regional trade agreements that seem to have boosted trade. Of course, these issues need further research.

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