Paraguay and Mercosur: A Sensitivity Analysis of Gravity Model Estimation Techniques

Victor Gauto
Department of Applied Economics
University of Minnesota
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Abstract

This paper analyzes the effects of Mercosur on Paraguay import flows by comparing the results of the traditional OLS estimator with two more recent techniques in the literature, recommended to adequately address zero trade flows: the Heckman correction for selection bias and the Poisson Pseudo-Maximum-Likelihood estimator. The specification of the three estimators is implemented using country fixed effects panel analysis of Paraguayan merchandise import values (SITC Rev.1) at the one digit level from 152 countries over period, 1970-2010. Additionally, I capture measures of trade creation and trade diversion in Paraguay since the creation of Mercosur in 1995, using a version of the difference-in-difference estimator. I compare the sensitivity of these measures across estimators and differing sample sizes. I find overwhelming evidence of trade creation. Additionally, the PPML measure of trade creation is about half that of the OLS estimator, a finding consistent with the literature. I generally find no evidence of trade diversion though a limited amount is observable using the PPML estimator analyzing Paraguay's 19 major trading partners only. Finally, I find no anticipatory effects of Mercosur and significant gains in trade creation towards the end of the sample period.

1. Introduction

Regional and bilateral trade agreements have proliferated around the world over the last thirty years. The World Trade Organization[1] recognizes 217 trade agreements currently in force, out of which 195 have been consummated since 1990. Mercosur and NAFTA are among the older of the more recent trade agreements having been created in 1991 and 1994, respectively. A well known phenomenon in international trade is that smaller, relatively narrow-based economies, the extreme of which are island economies and city states, tend to trade a larger share of their GDP than do larger more diversified economies (Frankel, 1997). Trade agreements between a small economy and larger economies are thus likely to have a larger effect on the share of the small economies' foreign trade in GDP. The net effect on small country welfare may be positive even if the agreement results in some trade diversion provided the gains from trade expansion that would not otherwise have occurred dominate the loss from diversion. Moreover, these gains or losses are likely to be far larger for a small economy. While there have been a plethora of studies investigating the effects of trade agreements, few have focused on small economies.

This paper presents a sensitivity analysis of various estimators used to capture the effects Mercosur has had on Paraguayan import flows. Created in 1991, Mercosur is a regional trade agreement (RTA), functioning as a customs union, in South America made up of Argentina, Brazil, Paraguay, and Uruguay. A recent study on Mercosur's common external tariff (CET) reported member tariff rates have changed as each country has gradually converged to the common external tariff. According to this study, Argentina, Brazil, and Uruguay have converged down to the CET and reduced average tariff rates by 50%, 33%, and 25%, respectively. On the contrary, Paraguay has

[1] http://rtais.wto.org/UI/PublicAllRTAList.aspx

converged up to the CET and increased average tariff rates by 50% (Berlinksi, 2005). This finding suggests Mercosur has raised Paraguay's barriers to international trade. Yet, hundreds of exemptions to the CET remain and negotiations on such product categories as 'capital goods' and 'information and communications technology' have continued[2]. Viner (1950) synthesized the benefits and losses of custom unions into the concepts of trade creation and trade diversion, respectively. Trade creation occurs when it is more efficient to import a good from a partner in a trade agreement than to produce it domestically, while trade diversion takes place when imports from efficient sources are shifted to inefficient sources that are benefitting from tariff preferences associated with membership to an RTA. The overall impact of Mercosur on Paraguay's import flows is the empirical question I attempt to answer.

The models estimated in this work rely on the gravity model of international trade. Often referred to as the 'workhorse' for empirical analyses of international trade, the gravity model's most basic form predicts the volume of trade between countries is a function the partner's GDPs, populations or GPD per capita, and distance. Introduced by Tinbergen (1962), it gained popularity after Anderson (1979), Bergstrand (1985), Helpman (1987), and Deardorff (1997) developed theoretical foundations for its implementation. More recently, the theoretical foundation developed by Anderson & van Wincoop (2003) removes GDP per capita from its specification and incorporates a *multilateral resistance term* to its specification reflecting country price indexes and trade barriers. Anderson & van Wincoop's (2003) was a cross-sectional analysis and Baldwin & Taglioni (2006) extended this theory to a dynamic environment. In the same spirit as the gravity model's abundance of theoretical foundations, the literature has been stirred with discussions about the 'correct' method of estimating gravity models (Matyas, 1997 & 1998; Egger, 2000; Anderson & van Wincoop, 2003; Baldwin & Taglioni, 2006; Linders & de Groot, 2006; and Martin & Pham, 2008).

Traditionally, studies have estimated the gravity equation on countries having positive trade (Frankel, 1997; Clausing, 2001; Feenstra, 2002; Fukao, Okuba, & Stern, 2003; Anderson & van Wincoop, 2003; and Baldwin & Taglioni, 2006). Consequently, any occurrence of 'zero trade flows' are discarded from the sample. One of the main criticisms of this approach is that the absence of trade between countries holds important information, which if ignored, produces biased estimates. One alternative to this method of ignoring 'missing' observations is to consider 'missing' observations as evidence of an absence of trade and impute zero-valued trade observations to the data set. Still, this creates additional problems since in the multiplicative exponential form the natural log of zero is undefined. Out of the several approaches suggested to deal with this problem, Silva & Tenreyro (2006) and Helpman et al. (2008) have been among the most influential. Silva & Tenreyro (2006) estimate the model using a Poisson Pseudo Maximum-Likelihood estimator (PPML), which in addition to producing unbiased estimates, is robust to heteroskedasticity in the error terms. Helpman et al. (2008) develop a theory predicting positive as well as zero trade flows between countries and propose a two-stage estimation procedure similar to a Heckman sample selection model.

[2] The Paraguayan Ministry of Finance reports extended exemptions for 1,200 capital goods and 390 information and communications technology items (http://www.hacienda.gov.py/web-hacienda/index.php?c=96&n=3335). Some examples of exempted goods are 'mobile cellular phones' (HS-2006 85171100) and 'personal computers' (HS-2006 84715010) which have a CET of 20% and 16% respectively. On the other hand, electrical appliances are an example of durables without exemptions, which have a CET of 20%.

Consequently, the objective of this study is to analyze the sensitivity of estimates of various econometric techniques. Specifically, I compare traditional Ordinary Least Squares estimates to those resulting from a Heckman sample selection model and a Poisson Pseudo Maximum-Likelihood estimator. Given the availability of a commodity-level panel data set over a forty year period, country fixed effects are included in all techniques which controls for country-level heterogeneity or multilateral resistance (Matyas, 1997; Egger, 2000; Anderson & van Wincoop, 2003). Moreover, I employ a re-parameterization of the difference-in-difference estimator to quantify the extent of trade creation and trade diversion of Paraguayan imports since Mercosur's creation. The sensitivity of these estimates is not only studied through different methodologies, but also through a reduction of the sample size by gradually eliminating countries with high frequencies of zero export flows to Paraguay. The share of zero trade flows can be quite large, especially at disaggregated levels.

A secondary objective of this study is to analyze the dynamic time path effects of Mercosur on Paraguayan import flows in an interval analysis. The literature is rich with suggestions that the formation of regional trade agreements between 'natural trading partners', usually neighboring countries trading disproportionately with each other, are likely to be welfare-improving (Wonnacott & Lutz, 1989; Krugman, 1991; and Summers,1991). Moreover, there are likely to be increases in regional trade around the time of the creation of an RTA as businesses position themselves to enter newly opened markets (Frankel, 1997; Magee, 2008). Additionally, the signing of an agreement does not imply immediate regional trade liberalization. There are usually lengthy transition periods from the moment an agreement is signed to its effective date. I analyze the time path of Paraguayan import flows in a 3-year interval analysis to test how levels of imports from Mercosur countries have evolved before and after its creation. Disproportionately high levels of regional imports occurring solely after Mercosur's adoption would be strongly attributable to this policy intervention.

Several studies based on the gravity model analyze multiple RTAs simultaneously. These studies may be further distinguished into cross-sectional or time series studies. Frankel (1997), which has been the basis of this research, reported regression results of yearly cross-sections at five year intervals. He also pooled several years of data available to him and treated RTAs in his model as fixed over time. This treatment of RTAs does not necessarily capture changes in trade since a policy intervention but it does give an indication of the evolution of regional trade. Similarly, Soloaga & Winters (2001) treated zero trade flows as a censoring problem and used a Tobit model on cross-sectional data. Magee (2008) was among the first in this literature to implicitly incorporate the time dimension into the analysis of RTAs. Moreover, he accounted for zero trade flows by using a fixed effects Poisson Pseudo Maximum-Likelihood estimator in one of the main specifications of his study. However, by including year fixed effects he precluded dummy variables capturing import flows from non-member countries due to collinearity issues. Studies including multiple RTAs are not only useful for analyzing individual groups but also to address the broader question of whether RTAs undermine the multilateral trade liberalization process[3].

Other studies based on the gravity model focus on single RTAs (Clausing, 2001; Fukao, Okubo, & Stern, 2003). Such studies, like this one, use the underlying variation in member and non-member

[3] Regionalism is said to undermine multilateral trade liberalization or act as a 'stumbling block' if RTAs hinder trade liberalization with non-member countries. Frankel (1997) finds that by his research countries entering liberal trade agreements also tend to open up with non-member trading partners, suggesting RTAs support multilateral trade liberalization or act as 'building blocks' for international free trade (p. 227).

preferences to identify the impact of an RTA on import flows from member and non-member countries. Clausing (2001) used data on trade and tariffs from 1989 to 1994 to study the effects of the Canada-US Free Trade Agreement (CUSFTA, the predecessor of NAFTA) on Canadian export flows to the US. Fukao, Okubo, & Stern (2003) focused on the effects of NAFTA on US import flows from 1992 to 1998. Their principal specification was a panel country and year fixed effects gravity model using highly disaggregated trade values. Considering they used shares of imports as their dependent variable, their specification did not permit an explicit analysis of import flows from non-member countries. Like Clausing (2001), they used a truncated data set.

The inclusion of measures for both, trade creation and trade diversion, in studying the impact of RTAs on an individual country in a dynamic time path environment is a contribution to this literature. My study is similar to Magee's (2008) to the extent I include a time path analysis of regional trade and similar to Fukao (2003) to the extent I focus on a single RTA. However, I depart from these studies by including a measure for trade diversion in the analysis of import flows.

2. Data and Methodology

2.1. Data

The data collected for this work include import values, US CPI, real GDP, real GDP per capita, and real exchange rates from 1970 to 2010. Additionally, I collected time invariant data such as bilateral distance between Paraguay and the exporter, language, land area, and religious similarities. Import values at the one digit level of disaggregation were retrieved from the UN Comtrade database. The selected commodity classification was the SITC Rev.1 which has data available for the most years, even before 1970. Import trade values were deflated using the US CPI. Geographic variables were collected from the CEPII (*Centre d'Etudes Prospectives et d'Informations Internationales*) and GDP related variables were collected from the USDA Economic Research Service.

During 1970-2010, there is sufficient data for variables to include 152 countries in a sample of countries exporting to Paraguay in at least a single year and single commodity[4]. The data set holds 13,209 positive valued observations, out of which less than 1% are less than $100. As explained in Frankel (1997) and mentioned earlier, missing observations in such trade data are attributable to the absence of trade between countries which may be due to the size of the trading economies or remoteness from each other. Considering Paraguay is a small landlocked country and the import values are at the one-digit level of detail, it is likely many countries do not export to Paraguay in all commodity codes in all years. In fact, no country in the data set exported to Paraguay in all commodities during all years. As part of this study, I enter these 'zero trade' observations to the data set which expands the number of observations in the data set to from 13,209 to 60,780[5].

[4] Some countries which have exported at least once to Paraguay during this period have been eliminated from the sample due to lack of data on the real exchange rate. This is the case of Afghanistan, Rwanda, and Zimbabwe.

[5] Each country can have a maximum of 410 observations (10 commodity codes X 41 years). As an example, if a country had 200 observations of positive exports to Paraguay I added the remaining 210 zero-valued export flows. I have also estimated the models to be presented by including only commodities of each country for which trade occurred at least once. This implies if a country has never exported 'silver' to Paraguay, then silver is removed from the data set for that country. Doing this substantially reduces the number of observations in the data set, but the results are equivalent among 2 of the 3 estimators in the study (OLS & Poisson) and minimally different using the Heckman specification.

2.2. The Gravity Model

The traditional and basic specification of the gravity model defines trade between two countries as a function of the product of their GDPs, the product of their GDPs per capita (or population), and the distance between them. Other variables that are also sometimes included control for cultural affinity. The inclusion of land area supplements economic size variables since it incorporates information about natural resources to the model. Countries with greater land area or GDPs are generally less dependent on trade (Frankel, 1997). The dependent variable varies across studies. Some studies use the sum of import and export flows as the dependent variable (Frankel, 1997; Bayoumi and Eichengreen, 1997) while others focus on a single trade flow, usually import flows, when the objective is to analyze trade diversion and trade creation (Soloaga & Winters, 2001; Fukao et al., 2003; Clausing, 2001; Magee, 2008). In this paper I also use bilateral import flows as the dependent variable and following Frankel (1997), the general specification for cross-sectional data, takes the following form:

$$\ln(I_{ij}) = \beta_0 + \beta_1 \ln(GDP_i * GDP_j) + \beta_2 \ln\left[\left(\frac{GDP}{pop}\right)_i \left(\frac{GDP}{pop}\right)_j\right] + \beta_3 ln(Dist_{ij}) + \beta_4(Lang_{ij}) + \varepsilon_{ij} \quad (1)$$

In this model, I_{ij} represents the value in current US dollars of country *i*'s imports from country *j*, the product of GDPs captures the size of the economies while the product of GDPs per capita gathers information on income and population. Distance is theorized to be inversely proportional to trade volumes and cultural affinity in the dummy variable for language ($Lang_{ij}$) is expected to enter the equation positively.

To analyze the effects of regional trade agreements, the specification above is usually augmented to include a set of dummy variables representing intrabloc and extrabloc trade. A positive and significant coefficient on the parameter representing membership is interpreted as trade in excess of what is predicted by the gravity model and is considered evidence of trade creation. A negative and significant coefficient on the dummy variable for extrabloc trade is evidence of less trade than predicted by the basic specification, and interpreted as evidence of trade diversion. Consequently, the magnitudes of these parameters play a significant role in determining what the overall effect of a regional trade agreement has been for a country or group of countries.

2.3. The difference-in-difference estimator

A criticism of some RTA studies based on the gravity model is that often, researchers assume any increase to regional trade since the signing of an agreement is mostly attributable to the agreement, ignoring the possibility that cultural and historical links have played a significant role in explaining disproportionately high levels of trade between neighbors and even the formation of regional trade agreements (Magee, 2008; Soloaga & Winters, 2001, Bayoumi & Eichengreen, 1995). Such studies are often cross-sectional, and often treat the existence of an RTA as fixed over time. The implication of this criticism is that the formation of an RTA is correlated with the error term resulting in biased estimates. Incorporating the time dimension into the analysis permits the utilization of the difference-in-difference estimator, which is useful to capture valuations of any increase in regional imports since the creation of an RTA in excess of the trade attributable to historical or cultural ties.

Although unapparent with country fixed effects in the specification, I utilize a re-parameterization of the difference-in-difference estimator and combine it with the gravity model to obtain parameters which measure the magnitude of the impact of Mercosur on Paraguayan imports from both member and non-member countries. For practical purposes, this methodology treats member countries as part of a treatment group and remaining trading partners as controls.

The application of the difference-in-difference estimator to Paraguayan aggregated import flows takes the following form:

$$\ln(I_{jt}) = \gamma_0 + \gamma_1 Post_t + \gamma_2 Mercosur_j + \gamma_3 (Post_t \cdot Mercosur_j) + \varepsilon_{jt} \quad (2)$$

The subscript *j* on the dependent variable indexes the exporters to Paraguay, while t indexes years[6]. The variable $Post$ is a dummy taking a value of one for all years since the creation of Mercosur. The variable $Mercosur$ (M) takes a value of one for all Mercosur member countries for all years. Finally, $Post \cdot Mercosur$ (PM) is the interaction of these two dummy variables and consequently, γ_3 is the average treatment effect of the Mercosur policy variable. That is, the variable *PM* represents membership to Mercosur, so I will use *Members* and *PM* interchangeably from here on. After exponentiating *PM*[7], it represents the average percent change in imports from non-member countries subtracted from the average percent change in imports from member countries for two given periods. More formally,

$$\gamma_3 = \left[\overline{\ln(I_{M2})} - \overline{\ln(I_{M1})}\right] - \left[\overline{\ln(I_{NM2})} - \overline{\ln(I_{NM1})}\right] \quad (3)$$

where the subscript *M* refers to Mercosur countries and *NM* to non-Mercosur countries, while the subscripts *1* and *2* refer to the years before and after the creation of Mercosur, respectively.

Intuitively, the average gain in percent change in imports from non-member countries before and after the creation of Mercosur is subtracted from the average gain in imports from members. This estimator controls for both cultural and historical links of member countries (embedded in '$Mercosur$' of equation (2). '$Post$' in the same expression captures aggregate or time factors, that would have affected trade flows of both members and non-members even if Mercosur had not been created (Wooldridge, 2002).

The concepts of trade creation and trade diversion are implicit in γ_3 of expression (3). To make these concepts explicit I reparameterized the difference-in-difference specification in (2) as follows:

$$\ln(I_{jt}) = \gamma_0 + \gamma_2 M_j + \gamma_3 (PM)_{jt} + \gamma_4 (PNM)_{jt} + \varepsilon_{jt} \quad (4)$$

where *M* and *PM* have been previously defined and *PNM* $(Post \cdot NonMercosur)$ takes on a value of one for non-member countries since Mercosur's creation. This is justified given the previously defined dummy variable *Post* is a linear combination of *PM* and *PNM*

$$Post_t = (PM)_{jt} + (PNM)_{jt}. \quad (5)$$

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6 Noting Paraguay is the only importer in this context there is no longer any need to index importers.

7 The exact percent change in the predicted value of I when $Post \cdot Mercosur$=1 versus when $Post \cdot Mercosur$=0 is given by $100(e^{\gamma_3} - 1)$.

This decomposition of the dummy variable $Post$ will facilitate the identification of the average percent change in import flows from member and non-member countries since Mercosur's creation. Hence, in the re-parameterized form (4), the coefficients have the following interpretation:

$$\gamma_3 = \overline{\ln(I_{M2})} - \overline{\ln(I_{M1})} \tag{6}$$

$$\gamma_4 = \overline{\ln(I_{NM2})} - \overline{\ln(I_{NM1})} \tag{7}$$

2.4. Country fixed effects

The benefit of this methodology is these difference estimators control for unobserved factors determining high or low levels of bilateral trade among members of an RTA. However, they do not control for similar unobserved factors with non-member countries. Consequently, the final refinement to the model is to incorporate country fixed effects which completes the controls of time-invariant unobserved factors of trade[8]. Moreover, time-invariant observed variables are accounted for in this specification and are consequently removed from the model. However, that the difference variables, *PM* and *PNM* (γ_3 and γ_4) remain in the specification and their interpretation is unchanged.

3. Specifications

The models covered in this section describe the three estimators that will be used to compare measures of trade creation and trade diversion in Paraguay. The motivation behind this exercise is to analyze the consistency of the estimates across different estimators. These estimators are the pooled Ordinary Least Squares (OLS), the Heckman sample selection model, and the Poisson Pseudo Maximum Likelihood (PPML) estimator. In addition to country fixed effects, all models are estimated using robust standard errors in order to correct for serial correlation and heteroskedasticity in the error terms (Wooldridge, 2002). I also discuss a sample size reduction exercise use in analyzing the sensitivity of the various estimators. The last section discusses an interval analysis aimed at gathering how trade with Mercosur countries has evolved over time.

3.1. Sensitivity Analysis

As stated earlier a very large share of the data set is represented by zero trade flows or censored observations. These occur for mostly two reasons, it may be that trade between certain countries is rounded to zero and consequently goes unrecorded or there is genuinely no trade between two countries in a given year. It is very likely no trade takes place between small, developing, remote countries. Consequently, it is not surprising that in my data set there are very few occurrences of trade in any merchandise category with numerous countries[9]. Such observations can make up to 50% of the observations in studies involving multiple developed countries. In this initial data set, they make up 78% of the observations.

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[8] This practice has been widely used and recommended in the works of Matyas (1997), Egger (2000), Feenstra (2002), as well as Anderson & van Coop (2003). In this last reference, country fixed effects control for multilateral resistance.

[9] Burundi, Botswana, Namibia, and even Suriname which is in South America are examples of countries with which Paraguay has had an occurrence of trade in a single merchandise classification during the sample period.

Alternatives to discarding them the zero-valued observations include their substitution for a small constant such as $1000. This permits the OLS estimation of the log-linear gravity model but may cause additional difficulties since including a large number of censored values into the model specification may exacerbate heteroskedasticity in the error terms which produces biased and inefficient estimates. Another approach is to estimate the gravity equations using Tobit estimator given trade values are bounded from below by zero, an approach followed by Soloaga & Winters (2001). However Linders & de Groot (2006) questioned the appropriateness of this method given the Tobit model requires censored data to reflect either 'desired negative trade' or the rounding to zero of very small values of trade, both of which do not occur. Still, some researchers who have followed any of these approaches claim their results are robust to the inclusion of the zero-valued observations or not (Frankel, 1997; Soloaga & Winters 2001), minimizing the need for any correction.

Recently, two techniques to address these problems have been recommended in the influential papers of Silva & Tenreyro (2006) and Helpman et al. (2008). Silva & Tenreyro (2006) propose the use of a Poisson Pseudo Maximum-Likelihood (PPML) estimator for gravity models while Helpman et al. (2008) treat the presence of zero trade flows as a sample selection problem and recommend a two-step estimation procedure similar to the Heckman selection model. Silva & Tenreyro (2006) argue the PPML estimator addresses two challenges of estimating gravity equations. First, if the gravity model takes a multiplicative exponential form and the error term is heteroskedastic, estimating such models using OLS after log-linearization leads to inconsistent estimates of the parameters of interest. The underlying reason for this is the expected value of the logarithm of the error term depends on its mean and variance. If the variance of the error term in the multiplicative exponential form is a function of other regressors in the model, as may be the case under heteroskedasticity, the log of the error term will also depend on these regressors. This correlation violates the condition for consistency of OLS. Consequently, the authors recommend estimating such models in the multiplicative exponential form. Second, given this recommendation, zero-valued observations no longer pose a challenge since trade flows are in levels instead of logs. Additionally, the authors assessed the empirical performance of PPML using Monte Carlo simulations. They found this estimator to generate more accurate results than several alternative estimators such as OLS on a truncated data set, Tobit, and OLS on $\ln(1+Trade_{ij})$[10].

The second technique proposes estimating the gravity model with a correction for sample selection bias (Helpman et al., 2008; Linders & de Groot, 2006. Helpman et al. (2008) develop a theory predicting positive as well as zero trade flows between countries, which their two-stage estimation procedure is based on. In the first stage they model the probability of trade occurring while the second stage reflects the gravity equation with a correction for sample selection as well as firm heterogeneity, making it similar to a Heckman sample selection model. This procedure will be discussed in more detail later, but it hinges on finding a suitable 'exclusion restriction', which may be difficult to find[11]. Helpman et al. (2008) successfully use an index for 'religion' as their exclusion restriction. However, such a variable is differenced out of models with fixed effects which is why the Heckman model in this paper does not have such an exclusion restriction. As the reader will see, it is possible to do so but not ideal, reflecting a disadvantage of the Heckman sample selection correction over the PPML estimator in this context.

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[10] The Tobit analyzed in this study is the Eaton and Tamura (1994) Tobit model, also referred to in Martin (2008).

[11] The exclusion restriction requires a variable to be correlated with inclusion in the sample (dependent variable in the selection equation), but uncorrelated with the error term in the outcome equation.

I estimate three models, a traditional OLS model on the truncated data set, as well as the Heckman and PPML models to evaluate the consistency of my findings regarding trade creation and trade diversion. In what follows, I state the specifications used in each case.

3.1.1. Pooled OLS with Country and 'Event' Fixed Effects

The benchmark specification in this work is a pooled cross-sectional Ordinary Least Squares (OLS) model with event and country fixed effects taking the following form:

$$\begin{aligned}\ln(I_{kjt}) = \beta_0 + \beta_1 t + \beta_2 \ln(GDP_{Pyt} \cdot GDP_{jt}) + \beta_3 \ln\left[\left(\frac{GDP}{pop}\right)_{Pyt}\left(\frac{GDP}{pop}\right)_{jt}\right] \\ + \beta_4 \ln[RER_{Pyt} \cdot RER_{jt}] + \gamma_3(PM_{jt}) + \gamma_4(PNM_{jt}) + D_{73} + D_{79} + D_{82} \\ + D_{84} + D_{89} + D_{90} + D_{91} + D_{94} + D_{95} + D_{97} + D_{99} + D_{02} + C_1 + \cdots \\ + C_N + \varepsilon_{kjt} \\ for\ j = 1, \ldots, N\end{aligned} \quad (8)$$

Recall the data are at the one digit level of commodity disaggregation so the subscript k indexes commodities[12]. Considering only Paraguayan imports are analyzed, the subscript *j* indexes exporting countries and *Py* reflects Paraguayan values. Parameters β_2 and β_3 reflect traditional gravity variables used to predict 'natural' flows of trade from the rest of the world to Paraguay. The product of the real exchange rates (*RER*) is also included in this specification considering the time dimension is an essential component of this data set (Bayoumi & Eichengreen, 1997; Winters & Soloaga, 2001). The *RER* is defined as each country's real exchange rate versus the US dollar, so an increase in its value reflects a real depreciation of local purchasing power. Parameters γ_3 and γ_4 in (8) reflect the re-parameterization of the difference-in-difference estimator used to capture measures of trade creation and trade diversion[13]. I use 1995 as the start year for Mercosur considering it was the year regional trade was originally planned to be liberated, as well as when convergence to the common external tariff began. The C_j represent country fixed effects.

The models in this study include a linear time trend in the specification intended to capture trending such as global inflation and economic growth. This is a departure from the usual practice in the literature which is to include year fixed effects. Year fixed effects are omitted because of an almost perfect linear combination with the trade diversion parameter, γ_4. However, to improve the accuracy of the estimates, I include dummy variables for major political and macroeconomic shocks which are unlikely to be adequately accounted for by the linear time trend variable. These are represented by the D_t dummy variables in (8) which are detailed in Table 2 below.

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[12] There are ten commodity codes in the data set are: S1-0 Food and live animals; S1-1 Beverages and tobacco; S1-2 Crude materials, inedible, except fuels; S1-3 Mineral fuels, lubricants and related materials; S1-4 Animal and vegetable oils and fats; S1-5 Chemicals; S1-6 Manufactured goods classified chiefly by material; S1-7 Machinery and transport equipment; S1-8 Miscellaneous manufactured articles; S1-9 Commodities & transactions not classified according to kind.

[13] Recall M_j included in the difference-in-difference specification is time invariant and dropped with fixed effects.

Table 2 Event fixed effects included in the model specifications.

Year	Event
1973	1st Oil Crises
1979	2nd Oil Crises
1982	Falklands War
1984	Operations of hydroelectric Itaipú dam begin in 1984.
1989	Argentine hyperinflation. Democratic government in Paraguay.
1990	Brazilian hyperinflation.
1991	Mercosur agreement is signed.
1994	Brazilian inflation and Mexican financial crises.
1995	Start of Mercosur policies and Paraguayan financial crisis.
1997	Asian financial crises.
1999	Brazilian recession and end of *Plan Real*.*
2002	Argentine financial crises and end of *Plan Convertibilidad*.**

**Plan Real*: Brazilian exchange rate policy from 1994-1999, flexible peg local currency to U.S. dollar.
***Plan Convertibilidad*: Argentine fixed exchange rate policy from 1991-2002. This was a currency board where the local currency was fixed to the U.S. dollar by law.

3.1.2. Heckman Sample Selection Model

I also implement a Heckman sample selection model with accounts for the zero-valued trade observations discarded using traditional OLS methods. This is a two-step procedure where in the first stage or selection equation the existence of a trading relationship is modeled using a probit estimator. Hence, the positive-valued trade observations take a value of one and the remaining 'missing' observations zero. The predicted values of this model are used to construct the inverse Mills ratio, which is augmented to the outcome equation in the second stage, the gravity model in this application. The gravity equation is estimated on the uncensored observations only. As in the benchmark, this model is estimated using country fixed effects.

This model takes the following form:

Selection Equation:

$$\begin{aligned} T_{kjt} = \beta_0 + \beta_1 t + \beta_2 \log(GDP_{Pyt} \cdot GDP_{jt}) + \beta_3 \log\left[\left(\frac{GDP}{pop}\right)_{Pyt}\left(\frac{GDP}{pop}\right)_{jt}\right] \\ + \beta_4 \ln[RER_{Pyt} \cdot RER_{jt}] + \gamma_3(PM_{jt}) + \gamma_4(PNM_{jt}) + D_{73} + D_{79} + D_{82} \\ + D_{84} + D_{89} + D_{90} + D_{91} + D_{94} + D_{95} + D_{97} + D_{99} + D_{02} + C_1 + \cdots \\ + C_N + u_{kjt} \\ \text{for } j = 1, \dots, N \end{aligned} \qquad (9)$$

$$T_j = \begin{cases} 1 & Trade\,Volume > 0 \\ 0 & Trade\,Volume = 0 \end{cases}$$

Outcome Equation:

$$\ln(I_{kjt}) = \beta_0 + \beta_1 t + \beta_2 \log(GDP_{Pyt} \cdot GDP_{jt}) + \beta_3 \log\left[\left(\frac{GDP}{pop}\right)_{Pyt}\left(\frac{GDP}{pop}\right)_{jt}\right] +$$

$$\beta_4 \ln\left[RER_{Pyt} \cdot RER_{jt}\right] + \gamma_3\left(PM_{jt}\right) + \gamma_4\left(PNM_{jt}\right) + \lambda\left(\hat{T}_{kjt}\right) + D_{73} + D_{79} + D_{82} + D_{84} + D_{89} + D_{90} + D_{91} + D_{94} + D_{95} + D_{97} + D_{99} + D_{02} + C_1 + \cdots + C_N + \theta_{kjt}$$

$$\text{for } j = 1, \dots, N$$

This approach has several advantages. First, it adds flexibility to the comparable Tobit model, which restricts the censoring mechanism to be part of the outcome equation. The two-step procedure models the processes separately. Using an OLS estimator in the second stage rather than maximum-likelihood methods permits the adoption of weaker distributional assumptions of the joint distribution of the error terms of both models (Cameron and Travedi, 2005). A priori, any potential correlation between the error terms of the first and second stages can be verified and corrected by this procedure. A lack of correlation between the error terms Cov($\varepsilon_{kjt}, u_{kjt}$)=0, is indicative of no sample selection bias. Note ε_{kjt} refers to the error term of the model prior to the implementation of the correction procedure.

This specification usually requires the existence of a suitable 'exclusion restriction'. The exclusion restriction requires a variable to be correlated with inclusion in the sample (dependent variable in the selection equation), but uncorrelated with the error term in the outcome equation. Helpman et al. (2008) constructed a 'religion' index increasing in similarity between trading partners. However, this is a time invariant index and not suitable for a specification with country fixed effects. As a result, this model does not include an exclusion restriction which is possible, but likely to introduce multicollinearity into the outcome equation. However, in such exercises multicollinearity is attenuated by the extent of variation in the explanatory variables of the selection equation, that is, the better the probit model distinguishes between trading and non-trading partners (p. 551 Cameron & Travedi, 2005; p. 564 Wooldridge, 2002). Although the lack of a suitable exclusion restriction is a weakness of this model, I propose multicollinearity does not pose a threat to the identification of this model considering the large number of countries and years in the data set.

3.1.3. Poisson Pseudo-Maximum Likelihood Estimator

As discussed above, estimating the linearized form of the gravity model (through taking the log of both sides) will lead to inconsistent estimates when the variance of the error term in the untransformed gravity model depends on the explanatory variables. Silva & Tenreyro (2006) first derives a general form of a multiplicative exponential form of the gravity model and then propose to use the *Poisson Pseudo Maximum Likelihood* (PPML) estimator. Although PPML is usually used for count data, the authors argue that it is numerically equivalent to the Non-linear Least Squares (NLS) estimator that could be used to estimate the multiplicative exponential model[14]. It is easy to compute the robust variance-covariance matrix in the PPML estimator to address heteroskedastic error terms in the multiplicative exponential form. Finally, since trade flows (the dependent

[14] This refers directly to equations (6) and (7) in Silva & Tenreyro (2006), where (6) is the general form of the multiplicative exponential model,

$$y_i = \exp(x_i\beta) + \varepsilon_i$$

which can also be expressed as,

$$y_i = \exp(x_i\beta)\,\eta_i.$$

This equation is transformed by taking the logarithm of both sides, leading to equation (7) in Silva & Tenreyro (2006)

$$\ln y_i = x_i\beta + \ln \eta_i.$$

variable) are in levels (not in logs), zero-trade flows do not pose any problem in the estimation procedure.

Silva & Tenreyro (2006) study this estimator on cross-sectional data. However, this estimator has been implemented in panel data environments[15], which is what I estimate. For this application, I implement the above estimator using the following specification:

$$I_{kjt} = \exp\left\{\beta_0 + \beta_1 t + \beta_2 \ln\left(GDP_{Pyt} \cdot GDP_{jt}\right) + \beta_3 \ln\left[\left(\frac{GDP}{pop}\right)_{Pyt}\left(\frac{GDP}{pop}\right)_{jt}\right] + \beta_4 \ln\left[RER_{Pyt} \cdot RER_{jt}\right] + \gamma_3 PM_{jt} + \gamma_4 PNM_{jt} + C_1 + \quad \ldots + C_N\right\} + \varepsilon_{kjt} \qquad (10)$$

$$for\ j = 1, \ldots, N.$$

an application of the general from,

$$I_{kjt} = \exp\left(\boldsymbol{x}'_{\boldsymbol{jt}}\hat{\beta}\right) + \varepsilon_{kjt}\ . \qquad (11)$$

Then from equation (11), minimized squared errors lead to the following set of K *m* first order conditions for panel data:

$$\sum_{j=1}^{N}\sum_{t=1}^{T}\left[I_{kjt} - \exp\left(\boldsymbol{x}'_{\boldsymbol{jt}}\hat{\beta}\right)\right]\exp\left(\boldsymbol{x}'_{\boldsymbol{jt}}\hat{\beta}\right)\boldsymbol{x}'_{\boldsymbol{jmt}}\hat{\beta} = 0 \qquad (12)$$

$$m = 1, \ldots, M.$$

M is the number of explanatory variables pus constant terms.

3.2. Sensitivity to sample size

Estimating the PPML and Heckman sample selection models in-full, implies imputing 47,571 zero-valued observations to the data set, which represent 78% of all observations. Considering the disproportionate number of zero trade observations in the full zero-imputed data set, I gradually remove countries with a low number of trade occurrences with Paraguay during the sample period, with the objective of reducing the censored share of observations to less than 20%[16]. This discussion focuses on analyzing the sensitivity of the trade creation and trade diversion parameters and the statistical significance of the remaining explanatory variables as the sample size decreases.

Table 3 describes the various samples that were used to estimate the three main models in this work. Each country may have a total of 410 (10 merchandise categories x 41 years) frequencies of trade with Paraguay. The first row in Table 3 describes the full data set representing 100% of Paraguayan imports from all countries for 1970-2010. The second row describes the data set where countries

[15] It is noteworthy, that while Silva & Tenreyro (2006) recommend estimating the gravity model in levels, Magee (2008) took the log of the dependent variable using the fixed effect PPML estimator.

[16] Cameron & Travedi (2005) list seven studies with the share of zeros in the data set range from 20 – 90% (p. 666).

with fewer than 41 frequencies of trade with Paraguay are removed. Notice the sample size is reduced to 26,860 while the share of censored observations decreases to 54%. Still, the share of trade in this sample represents 99.6% of trade relative to the full data set.

Table 3 Sample Sizes used to estimate the Poisson, Heckman, and OLS models.

Frequencies	N	Zeros	Censored	% of Total Trade
Full	60,780	47,571	78%	100%
<41	26,860	14,457	54%	99.6%
<124	18,040	7,190	40%	97.4%
<138	16,400	6,073	37%	80.8%
<200	11,070	2,876	26%	77.6%
<250	7,790	1,395	18%	74.9%

There is a noticeable decrease in the share of total trade in the sample when the sample size is reduced to 16,400 observations. Notice the share of total trade decreases from 97.4% to 80.8%, which responds to the removal of 'China' from the data set[17]. The smallest data set holds 7,790 observations where 6,395 observations have positive import values, representing 74.9% of all Paraguayan import values for the sample period. The censored observations in this smallest data set are reduced to 18%.

3.3. Interval Analysis

Finally, I introduce an interval analysis of Mercosur imports. The objective of this exercise is to identify whether there is a noticeable 'a priori' influence of Mercosur as often described in the literature. This exercise may also illustrate whether regional trade has been disproportionately high, or whether recent increases in regional trade may be genuinely attributable to the creation of Mercosur. I use the full data set to estimate the three models with adjustments to their specification for the interval analysis.

The standard models of the previous section compare levels of import flows from member and non-member countries before and after 1995, implying the base years for this comparison are 1970-1994. To capture 'a priori' effects of the agreement the base years are reduced to 1970-1979 and three year dummy variables for membership to the agreement are included from 1980 and on[18]. Hence, while the previous set of models capture average changes in the levels of trade at a single point in time, the interval analysis captures changes in the level of trade at ten distinct three-year intervals.[19] The 10 year period from 1970-79 is considered a sufficiently long and representative period to compare more recent years against. A shorter (longer) period would make finding a significant difference relative to that period easier (more difficult) because import flows in the early 1970s may have been

[17] The treatment of China in this data set may be challenging, considering Paraguay holds diplomatic relations with Taiwan rather than China, while the UN Comtrade database recognizes the People's Republic of China rather than Taiwan.

[18] Three year intervals collapse three years of data into a single estimate and smoothens estimates for years including extraordinarily high or low values of import flows from neighboring countries.

[19] The dummy variable for the last interval is actually a four year interval due to the number of years in the exercise (2007-2010).

disproportionately low compared to current levels (because import flows into the late 1980s may be less distinguishable from current levels).

A general specification holding the dynamic time path of trade creation is proposed in (13):

$$\begin{aligned} Imports_{kjt} = {} & \beta_0 + \beta_1 t + \beta_2 \ln(GDP_{Pyt} \cdot GDP_{jt}) + \beta_3 \ln\left[\left(\frac{GDP}{pop}\right)_{Pyt} \left(\frac{GDP}{pop}\right)_{jt}\right] \\ & + \beta_4 \ln[RER_{Pyt} \cdot RER_{jt}] + \delta_1(PM_{j8082}) + \delta_2(PM_{j8385}) \\ & + \delta_3(PM_{j8688}) + \delta_4(PM_{j8991}) + \delta_5(PM_{j9294}) + \delta_6(PM_{j9597}) \\ & + \delta_7(PM_{j9800}) + \delta_8(PM_{j0103}) + \delta_9(PM_{j0406}) + \delta_{10}(PM_{j0710}) \\ & + \gamma_4(PNM_{jt}) + C_1 + \cdots + C_N + \varepsilon_{kjt} \\ & \qquad for\ j = 1, \ldots, N \end{aligned} \tag{13}$$

The measure of each of the δ coefficients reflects the percent change in imports from Mercosur countries over the years it is indexed in comparison imports levels during the base years. Hence, if there are significant 'a priori' increase in regional trade before the creation of Mercosur one would expect δ_{8991} (1989-1991) or δ_{9294} (1992-1994) to be positive and statistically significant. The interpretation of γ_4 remains unchanged, it measures average percent change in levels of imports from non-member countries starting in 1995.

4. Results

4.1. Models with country and 'event' fixed effect using the full data set.

The first set of results reported in Table 4 compares the output of the three main models (8), (9), and (10), using the full data set. This data set includes a total of 152 countries holding 62,780 observations[20]. The estimates across the three models are consistent to the extent all coefficients have the same signs, but the statistical significance of these varies across the models. In the OLS model, the coefficients for *GDP*, *GDP per capita*, and *RER* are statistically significant. As predicted by theory, the results suggest imports increase in the product of country GDPs by 2.4% for every 1% increase in the product of country *GDPs*.

The same OLS model also obtains negative and statistically significant coefficients on *GDP per capita* and *RER*. The negative sign on *GDP per capita* is consistent with the Heckscher-Ohlin theory of trade (Frankel, 2007). By this theory, countries export resource-abundant products while they import resource-scarce varieties. Merchandise trade can be described to be made up of capital-, land-, and labor-intensive products. Similarly, countries with high capital endowments are likely to have higher wages due to their higher labor productivity levels[21]. Higher labor productivities are reflected in higher *GDP per capita* levels. This negative signs implies Paraguay is less likely to import or imports lower volumes from highly developed countries. While foreign *GDPs per capita* are driving the negative sign on this variable, Paraguay's own real exchange rate is driving the negative

[20] The list of 152 countries is reported in Table A.2 of the appendix.
[21] This argument borrows significantly from Carrere (2006), who described *GDP per capita* as a proxy for the capital-endowment ratio and hypothesized a negative sign on such a coefficient.

sign on the *RER* variable. That is, imports into Paraguay slightly decrease as the local currency depreciates (-0.11% for a 1% increase in the product of *RERs*). The 'difference' estimates measuring average percent change with Mercosur and non-Mercosur support a finding of great trade creation and no trade diversion. The estimate of 1.419 on PM, Member (γ_3) suggests regional imports have increase by 313% $[(e^{1.419} - 1) * 100]$ since 1995, while there has been no change in imports from non-member countries.

Table 5 Estimation Results with country fixed effects and full data set.

	Pooled OLS		Heckman two-step				Poisson	
			Selection		Outcome			
	β	p-val.	β	p-val.	β	p-val.	β	p-val.
Time (β_1)	-0.093**	0.00	-0.009**	0.01	-0.117**	0.00	-0.052	0.24
GDP (β_2)	2.420**	0.00	0.427**	0.00	3.150**	0.00	1.281	0.37
GDP per Cap. (β_3)	-1.318**	0.02	-0.104	0.13	-1.709**	0.00	1.175	0.47
RER (β_4)	-0.117*	0.09	-0.006	0.57	-0.128**	0.00	-0.250	0.16
PM, *Member* (γ_3)	1.419**	0.00	0.261**	0.05	1.407**	0.00	0.947**	0.00
PNM, *Non-member* (γ_4)	0.121	0.27	0.411**	0.00	0.467**	0.00	-0.027	0.83
1973	-0.021	0.81	0.103*	0.08	0.078	0.64	0.469**	0.02
1979	0.206*	0.05	0.084	0.12	0.260*	0.09	0.100**	0.03
1982	0.041	0.69	-0.029	0.60	0.003	0.99	-0.075	0.39
1984	-0.497**	0.00	-0.234**	0.00	-0.680**	0.00	-0.105	0.45
1989	-0.361**	0.00	-0.040	0.47	-0.399**	0.01	-0.268**	0.01
1991	0.248**	0.02	0.036	0.51	0.258*	0.08	0.153	0.14
1994	0.542**	0.00	0.185**	0.00	0.662**	0.00	0.399**	0.00
1995	0.000*	0.00	0.000**	0.00	0.000	0.25	0.000	0.68
1997	0.346*	0.00	-0.152**	0.00	0.198	0.15	0.007	0.95
1999	0.072	0.48	-0.267**	0.00	-0.153	0.29	-0.402**	0.00
2002	-0.247**	0.02	-0.149**	0.00	-0.362**	0.01	-0.221**	0.02
Constant	-79.99**	0.00	-20.05**	0.00	-20.05**	0.00		
Inverse Mills (λ)					1.548**	0.00		
Fixed Effects	Yes		Yes		Yes		Yes	
Countries	152		152		152		152	
Observations	13,209		60,780		13,209		60,780	

Note: *, **, *** imply significance at the 10%, 5%, and 1% levels, respectively.

The specifications incorporating the zero trade flows, the Heckman and Poisson models, do not contradict these results but modify them. An inspection of the outcome equation in the Heckman model reveals *GDP, GDP per capita,* and *RER* are highly statistically significant and have greater magnitudes than their counterparts of the OLS model. Similarly, the coefficient on the Inverse Mills (λ) is positive and statistically significant at the 95% confidence level, which is evidence of sample selection bias. Interestingly, none of these coefficients, *GDP, GDP per capita,* and *RER* are statistically significant in the Poisson model.

Regarding our main parameters of interest capturing trade creation and trade diversion, I find there is no qualitative difference across the estimators. Table 6 below summarizes my estimates for trade creation and trade diversion. The measures of tread creation (PM, *Member*) are statistically significant at the 95% confidence level using the three estimators. The magnitude of this measure in the Heckman model almost equals that of the OLS model, but the Poisson measure of trade creation is almost half of both (158%). This reduction in the effect of the regional trade agreement is consistent with the estimation of results of Silva & Tenreyo (2006), who also found a substantial decrease in realizing such comparisons. Finally, only the Heckman model estimate is statistically significant for the measure of trade diversion (PNM, *Non-member*). These findings suggest that on average, there has been no evidence of trade diversion in Paraguay since 1995.

Table 6 Measures of Trade Creation & Trade Diversion by Estimator and Inclusion of Event Fixed Effects.

	Pooled OLS	Heckman two-step	Poisson
PM, *Member* (γ_3)	313%***	308%***	158%***
PNM, *Non-member* (γ_4)	13%	60%***	-3%

Notes: FE abbreviates effects. All values calculated from estimates by $[(e^{\gamma_i} - 1) * 100]$ and '***' imply significance of the estimate at the 1% level.

Of the eleven event fixed effects included in the specifications, four are statistically significant in the three estimators: 1979, 1989, 1994, and 2002. The first is the year the second oil crises occurred. In 1989 the military dictatorship ended in Paraguay, and even though this was a political event, it is likely it also had economic ramifications. Two important economic events took place in 1994. First, Brazilian inflation levels reached a temporary high of 2,075% (WDI, World Bank). To address this crisis, Brazil implemented a currency stabilization policy called the *Plan Real* resulting in a currency stabilization which lasted approximately five years. It is likely this statistically significant coefficient may be capturing both macroeconomic shocks. Finally, 2002 is the year the *Plan Convertibilidad* in Argentina ended. The *Plan Convertibilidad* was a fixed exchange rate policy lasting approximately ten years in Argentina which ended with a grave financial crises and currency devaluation.

4.2. Sensitivity to sample size

An additional exercise involves analyzing the estimates after reducing the number of countries in the sample until only Paraguay's major exporting partners are included in the data set. This exercise was performed by gradually removing countries with very few export flows to Paraguay. Recall, if each country can potential have 410 export flows to Paraguay (41 years x 10 commodity classifications) countries with a single occurrence of trade are imputing 409 zero trade observations to the data set. The models were estimated using several sample sizes, the smallest of which included 19 of the 152 exporting partners. These 19 countries reflect those that have at least 250 trade frequencies with Paraguay and represent 75% of all imports over 41 years with respect to the original data set of 152 countries. This list of 19 countries is reported in Table A.2 of the Appendix.

There are two objectives in reducing the sample of countries in the data set. First, it will test the sensitivity of the trade creation and trade diversion estimates to number of countries used for the models. Second, it greatly reduces the ratio of zero import flows in the data set. For example, the share of zero trade flows in the smallest data set is 18%, much lower than the original 78%.

Table 7 Estimation Results with country fixed effects using the reduced data set.

	Pooled OLS		Heckman two-step				Poisson	
			Selection		Outcome			
	β	p-val.	β	p-val.	β	p-val.	β	p-val.
Time (β_1)	-0.158**	0.00	-0.060**	0.00	-0.086**	0.01	-0.050*	0.07
GDP (β_2)	5.108**	0.00	1.319**	0.00	3.768**	0.00	2.501**	0.00
GDP per Cap. (β_3)	-4.226**	0.00	-0.732*	0.04	-3.777**	0.00	-1.552*	0.08
RER (β_4)	-0.226	0.29	0.005	0.94	-0.283**	0.05	-0.370**	0.01
PM, *Member* (γ_3)	0.928**	0.00	0.496**	0.00	0.576*	0.06	0.547**	0.00
PNM, *Non-member* (γ_4)	0.092	0.47	0.315**	0.00	-0.302	0.22	-0.143*	0.10
1973	-0.080	0.44	-0.001	0.99	-0.112	0.67	0.147*	0.07
1979	0.339**	0.01	-0.181	0.11	0.561**	0.04	0.171**	0.00
1982	0.127	0.41	-0.140	0.22	0.307	0.24	0.053	0.56
1984	-0.321**	0.02	-0.131	0.24	-0.154	0.55	-0.016	0.91
1989	-0.323*	0.07	0.159	0.22	-0.451*	0.09	-0.189**	0.00
1991	0.196	0.16	-0.024	0.84	0.221	0.39	0.124	0.30
1994	0.522**	0.01	0.317**	0.02	0.201	0.48	0.348**	0.00
1995	0.000**	0.03	0.000	0.90	0.000	0.10	0.000	0.19
1997	0.242	0.11	-0.070	0.60	0.344	0.18	0.192**	0.04
1999	-0.183	0.28	-0.176	0.15	0.006	0.98	-0.304**	0.00
2002	-0.480**	0.01	0.024	0.85	-0.502*	0.05	-0.294**	0.01
Constant	-162.03**	0.00	-48.82**	0.00	-101.9**	0.00		
Inverse Mills (λ)					-3.151**	0.01		
Fixed Effects	Yes		Yes		Yes		Yes	
Countries	19		19		19		19	
Observations	6,395		7,790		6,395		7,790	

Note: *, **, *** imply significance at the 10%, 5%, and 1% levels, respectively. + The RESET test p-value indicates none of the models are incorrectly specified when in estimating the models on the reduced data of 19 major trading partners.

Table 7 reports the estimation results using the smallest data set previously discussed. Specifically, the sample holds 19 countries, 7,790 observations, and 18% of the observations are zero trade flows. Although some of the magnitudes differ substantially, from the estimates based on original sample sizes, the new coefficients are consistent in signs. The inverse Mills ratio continues to be statistically significant and therefore continues to support evidence of sample selection bias. Additionally, the number of statistically significant coefficients of the Poisson model almost doubles when the sample is reduced to the 19 major trading partners.

The magnitude of the gravity coefficients in the OLS model, *GDP* and GDP per capita, are much greater, increasing from 2.4 to 5.1 and -1.3 to -4.2, respectively. This is expected considering most of the countries in the reduced sample are industrialized country with relatively higher *GDPs* and

GDPs per capita than the countries in the full sample. That is, the higher scale of these variables is influencing the magnitudes of these coefficients. The pattern of greater magnitudes in the *GDP* and *GDP per capita* coefficients continues in the outcome equation of the Heckman model. Finally, while these coefficients were not statistically significant in the Poisson using the full data set, both become significant under the reduced data set. Once again the Poisson estimates are lower than those of the comparable OLS and Heckman estimates. Interestingly, the coefficient on *RER* is not statistically significant in the OLS model, but it remains negative and statistically significant in both the Heckman and the Poisson models. The relatively low magnitudes of the *RER* coefficients in both the Heckman and Poisson models, -0.28 and -0.37, respectively, suggest import volumes are relatively insensitive to currency depreciations.

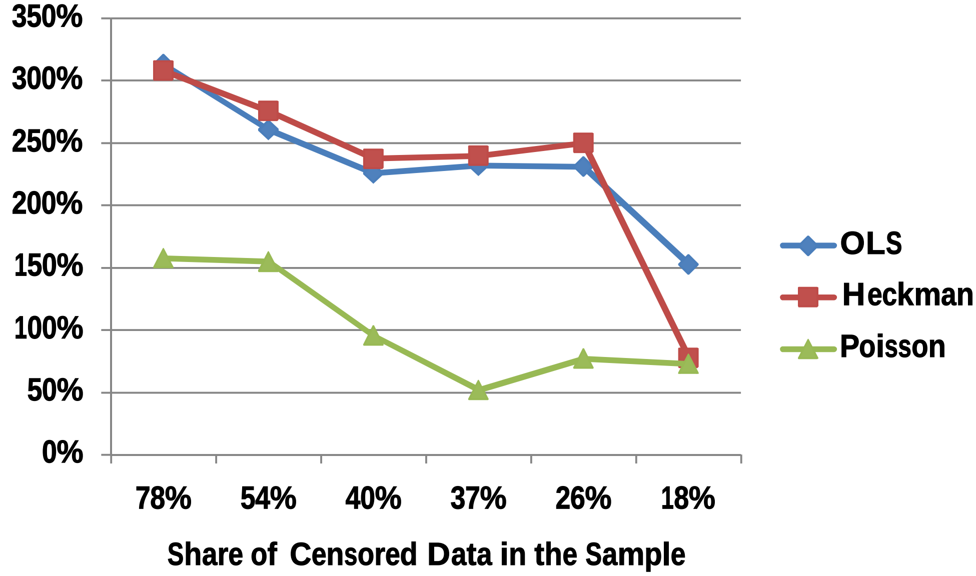
Finally, the parameters of interest measuring trade creation and trade diversion also remain consistent across the three models of the reduced sample. As before, the order of magnitudes are maintained with the estimate for Member (γ_3) being the greatest in the OLS model, followed by the Heckman and the Poisson estimates at 0.928, 0.576, and 0.547, respectively. These values are considerably lower than those estimated using the full sample (1.419, 1.407, 0.947), which illustrates that regional imports are disproportionate even when compared to only major international trading partners. These estimates imply imports from Mercosur countries have increased 153%, 78%, and 73% for each of the models, respectively.

Regarding the measure for trade diversion, *Non-member* (γ_4), once again I find no qualitative difference between the results based on the full and reduced data sets. None of the models of the full data set had a statistically significant coefficient at the 95% confidence level for this parameter, implying no evidence of trade diversion. The only slight departure from this statement is that the estimate for *Non-member* (γ_4) in the Poisson model was negative and statistically significant at the 90% confidence level. The estimate is -0.143 and its interpretation is that average level of imports from non-member countries has decreased by 13.36%, reflecting evidence of trade diversion. However, its magnitude is too low and its significance too weak, to make any reasonable claim of overall trade diversion in Paraguay attributable to Mercosur.

To further illustrate the variability of the different estimators of trade creation across different sample sizes, I summarize the measures of trade creation in Figure 2 below. This figure reports the measures of trade creation using multiple sample sizes beginning with 152 countries and gradually decreasing these to 66, 44, 40, 27, and finally 19 countries. The corresponding shares of censored observation are 78%, 54%, 40%, 37%, 26%, and 18%, respectively.

While the OLS estimates for trade creation across the various sample sizes decreases from 313% to 153%. Those of the Heckman model are very similar, starting at 308% but decreasing to 78% for the reduced data set (18% censored). Finally, the Poisson model estimates begin with 158% and end with 73%. All these estimates are statistically significant at the 95% confidence level with the exception of the estimate of the Heckman model with 18% of censored observations (it is significant at the 90% confidence level). The differences in magnitudes between the Poisson and other results are attributable to biases associated with estimating gravity equations using log-linear models Silva & Tenreyro (2006).

Figure 2 Measure of Trade Creation in Paraguay attributable to Mercosur by share of censored observations, 1970-2010.



For all shares of censored observations or sample sizes, the Poisson estimate is consistently below those of the OLS and Heckman methodologies demonstrating to be the most insensitive to sample size of all. The lower magnitudes of the Poisson estimates are consistent with the findings of Silva & Tenreyro (2006). As mentioned previously, these differences are attributable to biases associated to the inaccuracies of estimating gravity equations using log-linear models.

4.3. Interval Analysis

The results of the interval analysis discussed in the methods section are reported in Table 8. All models were estimated using the full data set and the coefficients on *GDP* and *GDP per capita,* as expected, are similar in magnitude to those reported in Table 5. All the *RER* coefficients reported in Table 8 are negative and statistically significant and their magnitudes is the greatest in the Poisson model (-0.373). As reported in Table 5, the coefficient on *Non-member* (γ_4) is positive and statistically significant in the Heckman model only. Its estimate in the Heckman model (0.481) implies an average increase in imports from non-member countries in the order of 62%. As a result, none of these models present any evidence of trade diversion, which is why I have not included a more detailed analysis of this parameter.

In terms of the event fixed effects, the statistically significant years across the three models are: 1989, 1994, and 2002 which are the year democracy began in Paraguay, the year of high Brazilian inflation, as well as the end of the *Plan Convertibilidad* in Argentina, respectively. These results are somewhat consistent with those reported in Table 5 with the exception that the *Plan Convertibilidad* was not statistically significant across all three models previously. Additionally, the 2nd oil crisis of 1979 was significant in all models reported in Table 5, but it is only significant at the 90% level of confidence in the OLS model of Table 8.

Table 8 Estimation Results of Interval Analysis, full data set and country fixed effects.

	Pooled OLS		Heckman two-step				Poisson	
			Selection		Outcome			
	β	p-val.	β	P-val.	β	P-val.	β	p-val.
Time (β_1)	-0.097**	0.00	-0.009**	0.01	-0.119**	0.00	-0.066	0.13
GDP (β_2)	2.429**	0.00	0.423**	0.00	3.135**	0.00	1.283	0.41
GDP per Cap. (β_3)	-1.297**	0.02	-0.105	0.13	-1.688**	0.00	1.323	0.45
RER (β_4)	-0.123*	0.08	-0.005	0.65	-0.131**	0.00	-0.373**	0.03
PM, 1980-82	0.138	0.26	0.184	0.46	0.075	0.82	-0.373**	0.03
PM, 1983-85	0.440**	0.00	-0.234	0.25	0.279	0.40	0.172	0.46
PM, 1986-88	-0.209	0.58	-0.317	0.12	-0.456	0.17	-0.150	0.64
PM, 1989-91	0.234	0.26	-0.085	0.71	0.070	0.83	0.220	0.58
PM, 1992-94	0.483	0.20	0.246	0.38	0.333	0.30	0.489	0.28
PM, 1995-97	1.236**	0.00	0.386	0.17	1.192**	0.00	1.035*	0.06
PM, 1998-00	1.242**	0.00	0.680*	0.05	1.210**	0.00	1.152*	0.06
PM, 2001-03	1.546**	0.00	0.130	0.61	1.426**	0.00	1.528**	0.02
PM, 2004-06	1.748**	0.00	-0.085	0.73	1.520**	0.00	1.529**	0.02
PM, 2007-10	2.142**	0.00	0.132	0.60	1.915**	0.00	1.408**	0.05
PNM, *Non-member* (γ_4)	0.176	0.11	0.406**	0.00	0.481**	0.00	0.194	0.23
1973	-0.028	0.75	0.102*	0.08	0.065	0.69	0.366**	0.03
1979	0.201*	0.06	0.085	0.12	0.249	0.10	-0.027	0.76
1982	0.030	0.77	-0.033	0.55	-0.003	0.98	-0.005	0.97
1984	-0.531**	0.00	-0.228**	0.00	-0.705**	0.00	-0.170	0.19
1989	-0.353**	0.00	-0.041	0.46	-0.393**	0.01	-0.224*	0.10
1991	0.261**	0.01	0.034	0.54	0.265*	0.07	0.195	0.12
1994	0.544**	0.00	0.179**	0.00	0.650**	0.00	0.357**	0.01
1995	0.000**	0.00	0.000**	0.00	0.000	0.19	0.000	0.64
1997	0.358**	0.00	-0.152**	0.00	0.219	0.11	0.054	0.69
1999	0.095	0.33	-0.272	0.00	-0.119	0.41	-0.344**	0.00
2002	-0.235**	0.02	-0.149**	0.00	-0.348**	0.01	-0.201**	0.02
Constant	-80.65**	0.00	-19.89**	0.00	-108.289**	0.00		
Inverse Mills (λ)					1.475**	0.00		
Fixed Effects	Yes		Yes		Yes		Yes	
Countries	152		152		152		152	
Observations	13,209		60,780		13,209		60,780	

Note: *, **, *** imply significance at the 10%, 5%, and 1% levels, respectively.

The main results in this section are related to the coefficients on the interval dummy variables representing three-year averages from 1980-1982 to 2007-2010, this last period being of four years for practical purposes. These coefficients measure how much imports from Mercosur countries have increased with respect to the average level of imports between 1970 and 1979, the base years.

A statistically significant result in any period dummy before 1995 is indicative of 'a priori' effects, an increase in trade related to firms presumably preparing themselves for business in soon to be more open markets. An inspection of the variables '*PM, 1980-82*', '*PM, 1983-85*', '*PM, 1986-88*', '*PM, 1989-91*' and '*PM, 1992-94*' reveals that none but *PM, 1983-85* are statistically significant in the OLS model. None of these coefficients are statistically significant in the Heckman model, and only *PM, 1980-82* is statistically significant with a negative sign in the Poisson model. These results not only suggest that there was no 'a priori' effect of Mercosur supporting the argument that the increases in regional trade observable after 1995 are genuinely attributable to the trade agreement.

The period dummy variables after 1995 illustrate how regional trade has evolved over time. An apparent trend in the period dummy variables since 1995 is that they are increasing in all models. These estimates capture the measure by how much imports have increased from Mercosur countries with respect to the group of base years 1970-1979. In short, these are measures of relative trade creation. The results are consistent in signs and statistical significance though the magnitudes of the period dummy variables vary by estimator.

Figure 3 Measure of Trade Creation in Paraguay attributable to Mercosur by three year intervals from 1995-2010.

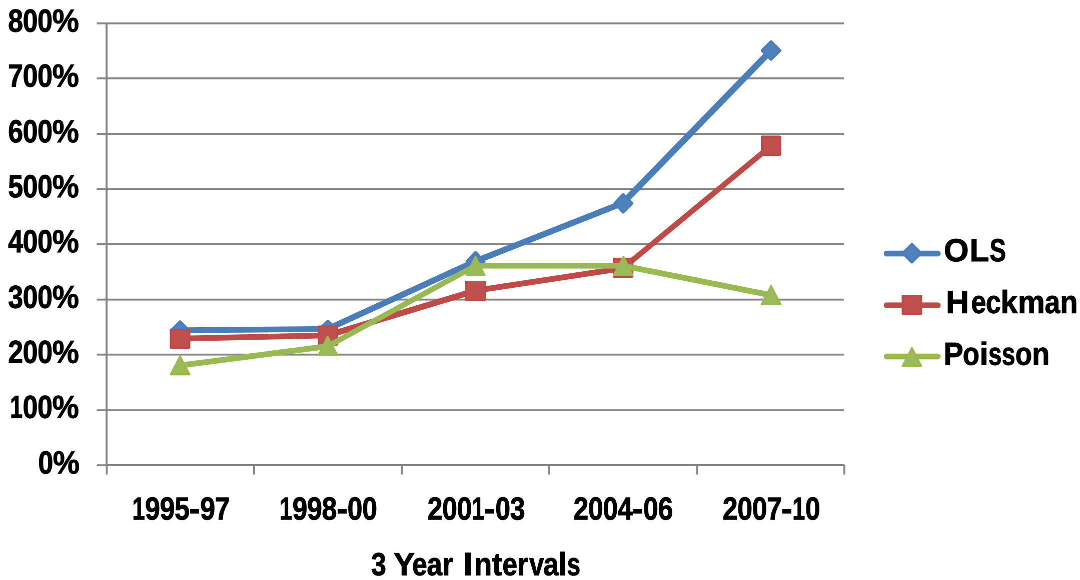


Figure 3 above presents a graphical depiction of the three-year average levels of import expansion from Mercosur countries beginning in 1995. The magnitudes of these average values are very similar from 1995-97 to 2001-03. The OLS estimates of trade creation are the highest in all years, with import expansions of 244% for the 1995-1997 period up to 751% during the 2007-2010. Similarly, the Heckman model attenuates these estimates by correcting for sample selection bias. The estimates of the Heckman model for the mentioned periods increase from 229% in the first three year interval to 579% in the final three year interval. Finally, the Poisson estimates are somewhat less variable and begin with a measure of 182% in the first three year interval increasing to a measure of 361% for the 2001-2003 period before decreasing slightly to 309% for the final four-year interval. The result of the final period dummy (2007-10) contradicts the increasing tendencies observed in the OLS and Heckman estimates. Nevertheless, these estimates reflect overwhelming evidence of trade creation and higher levels of regional trade in more recent years.

5. Conclusion

In this paper I used the gravity model of international trade to analyze how the creation of Mercosur has affected import flows into Paraguay and compared the results of more recently used estimators in gravity model applications. The main challenge in such studies is how 'zero trade flows' are addressed. After controlling for both country fixed effects as well as political and macroeconomic shocks, I compared a benchmark pooled OLS model to an application of the Heckman model and a Poisson model. While the Heckman model corrected an underestimation of 'gravity' variables in the pooled OLS estimates attributable to sample selection bias, there was no noticeable difference in the impact of membership to Mercosur between these two models. The Poisson estimates for trade creation were consistently lower than those of the previous model, a finding consistent with the seminal work of Silva & Tenreyro (2006). Additionally, in testing the sensitivity of the estimates to varying sample sizes or trading partners, I found that of the three estimates of trade creation the Poisson estimators had the least variation.

Additionally, a criticism of claims of trade creation in regional trade agreements is that it is difficult to disentangle the share of increase in trade attributable to the trade agreement and historical and cultural ties. Including fixed effects in the models addresses these criticisms. Moreover, by including period dummy variables I to check for 'a priori' effects supported my finding of the trade creating given I found no evidence of 'a priori' surges in regional imports. Much to the contrary, the main surges of regional imports occurred after Mercosur's creation, with even greater increases in imports in more recent times. These findings are strong evidence the trade creation observed in Paraguay is attributable to the trade agreement. Additionally, I found almost no evidence of trade diversion and the trace amounts found using the sample of major trading partners by the Poisson model is too slight to overturn this conclusion. Consequently, a trade agreement generating the benefits demonstrated in this work without the negative impacts attributed to trade diversion is beneficial for the economy as a whole.

6. Appendix

Table A.1 Full Data set of Exporting Countries to Paraguay 1970-2010*

Albania	Denmark	Kuwait	Rep. of Moldova
Algeria	Dominica	Kyrgyzstan	Romania
Angola	Dominican Rep.	Lao People's Dem. Rep.	Russian Federation
Argentina	Ecuador	Latvia	Saudi Arabia
Australia	Egypt	Lebanon	Senegal
Austria	El Salvador	Lesotho	Serbia
Bahamas	Equatorial Guinea	Liberia	Sierra Leone
Bahrain	Estonia	Libya	Singapore
Bangladesh	Ethiopia	Lithuania	Slovakia
Barbados	Finland	Luxembourg	Slovenia
Belarus	France	Madagascar	South Africa
Belgium	French Polynesia	Malaysia	Spain
Belize	FS Micronesia	Malta	Sri Lanka
Bermuda	Gabon	Mauritania	Sudan
Bolivia	Gambia	Mauritius	Suriname
Bosnia Herzegovina	Georgia	Mexico	Swaziland
Botswana	Germany	Mongolia	Sweden
Brazil	Ghana	Morocco	Switzerland
Brunei Darussalam	Greece	Mozambique	Syria
Bulgaria	Grenada	Myanmar	Tajikistan
Burundi	Guatemala	Namibia	TFYR of Macedonia
Cambodia	Guinea	Nepal	Thailand
Cameroon	Guyana	Netherlands	Togo
Canada	Haiti	New Caledonia	Trinidad and Tobago
Central African Rep.	Honduras	New Zealand	Tunisia
Chile	Hungary	Nicaragua	Turkey
China	Iceland	Niger	Turkmenistan
China, Hong Kong SAR	India	Nigeria	Uganda
China, Macao SAR	Indonesia	Norway	Ukraine
Colombia	Iran	Occ. Palestinian Terr.	United Arab Emirates
Congo	Iraq	Oman	United Kingdom
Costa Rica	Ireland	Pakistan	United Rep. of Tanzania
Côte d'Ivoire	Israel	Panama	Uruguay
Croatia	Italy	Peru	USA
Cuba	Jamaica	Philippines	Uzbekistan
Cyprus	Japan	Poland	Venezuela
Czech Rep.	Jordan	Portugal	Viet Nam
Dem. Rep. of the Congo	Kenya	Rep. of Korea	Yemen

*Afghanistan, Rwanda, and Zimbabwe have been removed from the sample due lack of *RER* data.

Table A.2 Reduced Data Set of Exporting Countries to Paraguay 1970-2010

USA	Japan
Argentina	Mexico
Belgium	Netherlands
Brazil	Rep. of Korea
Canada	Spain
Chile	Switzerland
Denmark	United Kingdom
France	Uruguay
Germany	USA
Italy	

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