Are estimation techniques neutral to estimate gravity equations? An application to the impact of EMU on third countries' exports.

Abstract

The gravity equation has been traditionally used to study the determinants of trade flows across countries. However, several problems related with its empirical application still remain unclear. In this paper, we provide a survey of the literature concerning the specification and estimation's method of this equation in last years. Additionally, we test the fit of different estimation procedures (Poisson, panel) using a large database. Our second objective is to assess the effect of the EMU on non EU countries exports, a question that hasn't been clearly answered until now.

* Classification JEL Code. C13, C33, F10, F15

Authors

Estrella Gómez Herrera (Universidad de Granada)

Juliette Milgram Baleix (Universidad de Granada)

Dto de Teoría e Historia económica

Facultad de Ciencias Económicas y Empresariales.

Universidad de Granada.

Campus de Cartuja, s/n.

18.011. Granada (Spain).

Telf.: +34 958 24 10 00 Ext 20145

Fax: +34 958 24 99 95.

Estrella Gómez [estrellagh@gmail.com]

Juliette Milgram Baleix [jmilgram@ugr.es]

1. Introduction

In the last fifty years, the gravity equation of trade has been widely used to predict trade flows. After the controversies concerning its theoretical foundation in the eighties and about its specification in the nineties, the estimation of gravity models went through an intense debate about estimations techniques in last years. Traditionally the multiplicative gravity model was linearised and estimated using OLS techniques, assuming that the variance of the error is constant across observations (homoscedasticity) or using panel techniques, assuming that the error is constant across countries or country-pairs. As pointed by Silva and Tenreyro (2006) in presence of heteroscedasticity, the Pseudo Poisson Maximum Likelihood (PPML) estimator performs better since OLS is not efficient. Another challenge of this literature concerns the zero values. Helpman et al. (2008) renewed this debate by proposing a theoretical foundation of these zero values based on a model with heterogeneity of firms à la Melitz and an adapted Heckman procedure to predict trade taking into account these features. Recently, the works of Burger et al. (2009), Martin and Pham (2008), Martínez-Zarzoso et al. (2007), Siliverstov and Schumacher (2007), Westerlund and Wilhelmsson (2007) have obtained some divergent results when comparing alternative estimators to deal with the heteroscedasticity and zero values problems.

The aim of this paper is twofold. Our prior objective is to contribute to the methodological debate on heteroscedasticity in these kinds of datasets and compare several estimation techniques. To this end, we use a gravity equation based on Anderson and van Wincoop (2003) model. We discuss the fit of different estimation procedures a large dataset of bilateral exports for 47 countries (80% of world trade) over the period 1980-2002.

Our second objective is to assess the effect of EMU on non EU countries exports, a question that hasn't been clearly answered until now. The sensitiveness of trade to exchange-rate regimes - defined in a de facto way by the level and the volatility of the exchange rate – is also explored. Additionally, we test how the euro affects trade among EMU countries and its imports from third countries by introducing dummies reflecting the fact that one or both partners belongs to the EMU. We compare how the coefficients of volatility of exchange rates and the dummies for trade and monetary agreements are affected by the different estimation techniques.

There is little debate about trade flows being determined by the behaviour of real exchange rates: even when market structures are taken into account (for instance when they give rise to pricing to market strategies) an appreciation in the real exchange rate leads to a worsening of the competitive position of the economy, and consequently to a rise in imports, and a fall in exports. This fact is now well documented, and is robust to the use of alternative measurement strategies even if aggregate demand and supply elasticities also depend on the structure of specialization in each country. The impact of exchange rate volatility on trade is more controversial, both in theory and empirical analysis. In theory, an increase in exchange rate volatility could either increase or decrease trade, depending on the risk aversion of firms or on the shape of the production functions. Looking at empirical analysis suggests that the measured effects of exchange-rate volatility on trade can be either very low and little significant or significantly negative, though minor in magnitude.

Though, monetary agreements may have an additional positive impact on trade flows once volatility reduction and exchange rate are controlled for as showed by Gil et al. (2009). Though, the question of the appropriate exchange rate strategy for the neighbors of the Eurozone and the impact it could have on third countries exports to these members is not completely solved.

To anticipate our most important findings, our study confirms that the estimation technique is not neutral to study the effect of exchange-rate regimes – defined by the level of and the volatility of the (real) exchange rate – on exports; though it doesn't matter so much for a basic model of trade flows. Different techniques lead to divergent results when the impact of EMU is studied. All in all, our results do not show strong diversion effects of the EMU.

The rest of the paper is organized as follows. In the next section we present the theoretical model. Section 3 details some of the most usual estimation methods in the gravity literature. In Section 4 the empirical model is presented, while Section 5 contains the econometric results. Some conclusions are provided in Section 6. The Figures and Tables are confined to the Appendix.

2. From the theory to the specification of the gravity equation

a) The model

The gravity equation of trade is highly effective at explaining bilateral flows as proven at a very early date by the works of Linnemann (1966) and Leamer and Stern (1971). However, this model threw several controversies. Theoretical framework was putted into doubt and afterwards justified: Bergstrand, 1989 for the factorial model; Deardorff, 1998 for the Hecksher-Ohlin model; Anderson, 1979 for goods differentiated according to their origin, Helpman, Melitz and Rubinstein, 2008 in the context of heterogeneity of firms. It seems that the H-O model would better explain the success of the gravity equation when the partners have very different factorial endowments, while increasing returns models would better explain the exchanges between similar countries precisely because the exchanges of differentiated goods represent a significant share of their trade.

In this paper we consider the augmented version of the Anderson (1979) model proposed by Anderson and van Wincoop (2003). They assume that goods are differentiated by origin; that each country is specialized in the production of only one good and preferences are identical, homothetic and approximated by a constant elasticity of substitution (CES) function. A world where goods are differentiated by origin may fit well with a sample of countries that are not completely similar regarding endowments and demand but not too heterogeneous; so taste for varieties may play an important role. This model is overall interesting to the extent that the discussion of the multilateral resistance may matter for the heteroscedasticity considerations. As it is well-known, these authors argued that *"remoteness" variable related to distance to all bilateral partners was a key variable for gravity models.*

The utility function is stated as:

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

where c_{ij} is consumption by importer j's consumers of goods from exporter i and σ is the elasticity of substitution between all goods. Consumer's constraint is given by:

$$y_j = \sum_i x_{ij} = \sum_i p_{ij} c_{ij} \quad (2)$$

where y_j is the nominal income of exporter i's residents, and p_{ij} is the price of exporter i's goods for importer j consumers. Prices differ among countries due to trade costs that are not directly observable. Trade costs are borne by the exporter and modeled as Krugman's iceberg costs. Given the exporter's supply price, p_i is then $p_{ij} = p_i t_{ij}$.

For each unity of good shipped from i to j the exporter incurs export costs equal to $t_{ij} - 1$ of country i goods. Solving the maximization problem of consumer j, they obtain the nominal demand from i goods in country j:

$$x_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j} \right)^{(1-\sigma)} y_j \quad (3)$$

where $x_{ij} = p_{ij} c_{ij}$ is the nominal value of exports from country i to j.

They identify three components of trade resistance: bilateral trade barriers between region i and j, (t_{ij}); i's resistance to trade with all regions (P_i) and j's resistance to trade with all regions (P_j). P_i and P_j are functions of that country's full set of bilateral trade resistance terms:

$$P_j = \left[\sum_i (\beta_i p_i t_{ij})^{1-\sigma} \right]^{1/(1-\sigma)} \quad \text{and} \quad P_i = \left[\sum_j (\beta_j p_j t_{ij})^{1-\sigma} \right]^{1/(1-\sigma)} \quad (4)$$

where β is a positive distribution parameter that denotes the share of country j in country i 's consumption. $y_i = \sum_j x_{ij}$ with the world income, $y^w \equiv \sum_j y_j$, lead to:

$$x_{ij} = \frac{y_i y_j}{y^w} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \quad (5)$$

As it can be appreciated, what matters in this specification is the bilateral trade cost *relative to* an overall index of trade costs, that is, bilateral trade resistance compared to multilateral trade resistance. Taking into account the relative prices also implies that trade barriers reduce trade between (and within) large countries more than between (and within) small ones.

Since t_{ij} is not observed, two assumptions must be added. First, costs are assumed to be symmetric. Second, t_{ij} is defined as a loglinear function of observables, bilateral distance and a dummy variable, b_{ij}, that takes value 1 if i and j are located in different countries, and it zero otherwise. Then

$$t_{ij} = b_{ij} d_{ij}^{\rho} \tag{6}$$

Substituting this term in the initial equation and taking logarithms with an error term and with k, the constant term, we would have a linear standard gravity equation:

$$\ln T_{ij} = k + \ln y_i + \ln y_j + (1-\sigma)\rho \ln d_{ij} + (1-\sigma)\ln b_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j + \varepsilon_{ij} \tag{7}$$

b) Multilateral Trade Resistance (MTR)

Anderson and van Wincoop's proposal was inspired by a pioneer article of McCallum (McCallum, 1995) that study the importance of border effects. Actually, they use the same database. Other articles related are Wei (1996), Helliwell (1998), Evans (2000), Head and Mayer (2000), Feenstra (2002), Gil-Pareja et al. (2005) or Cafiso (2008).

The most frequent empirical approach to measure the border effect is the gravity equation. The claim of Anderson and van Wincoop was that McCallum (1995)'s equation suffered from omission of variables that might translate in an overestimation of border effects since he did not include a measure of the multilateral trade resistance of each country. To solve that problem, they develop a new theoretical framework for the gravity equation that includes a theoretical specification for the multilateral resistance term. The specification is given by equation (8). Since the multilateral price indexes (P_i and P_j) are not observed, some alternatives have been proposed for estimation purposes.

The first option is to include price index data directly (Ruiz and Vilarubia 2007). This solution has never been used due to the lack of data or non homogeneity of the calculation methods among national sources.

The second solution, proposed by Anderson and vanWincoop (2003), is a non-linear estimation technique. To obtain the multilateral trade resistance terms, they use the observables in their model, which are distances, borders, and income shares. Assuming symmetric trade costs, using 41 goods market-equilibrium conditions[1] and a trade cost function defined in terms of observables, they are able to obtain the P_i and P_j terms. They argue that this method is more efficient than any other. However, the procedure is data consuming and has not been frequently used by other authors.

[1] In their sample, they use the same 30 US states and 10 Canadian provinces that McCallum (1995) includes. There are 20 additional states, plus Columbia, that they aggregate into one. Finally, they have 41 equations.

A third proposal in the literature is presented by Baier and Bergstrand (2006). They suggest to generate a linear approximation of the P_i and P_j terms by means of a first-order Taylor series expansion. This procedure is a little more complicated than simply including fixed effects, but it avoids the non-linear procedure employed by Anderson and vanWincoop (2003), and permits OLS estimation. Baier and Bergstrand's method is theoretically consistent and captures country specific and country-pair specific effects. However, as themselves note, bilateral trade barrier are not symmetric, and when this aspect is re-introduced in the model, it is not as simple as before.

A method frequently used is to include a proxy for these indexes called “remoteness variable”:

$$Rem_i = \sum_j \frac{dist_{ij}}{(GDP_j/GDP_{ROW})}$$

where the numerator would be bilateral distance among two countries, and the denominator would be the proportion of each country’s GDP to the rest of the world. Anderson and vanWincoop (2003) compare their previous results with a regression including a remoteness variable. They claim that a remoteness variable is not theoretically correct, since the only trade barrier it captures is distance. Even if distance were actually the only bilateral barrier, they argue that the way in which it is included in the remoteness index is not theoretically justified.

Head and Mayer's (2000) remoteness variable describes the full range of potential suppliers to a given importer, taking into account their size, distance and relevant costs of crossing the border. Wei (1996), Wolf (1997), and Helliwell (1997) are other examples of regressions that include a remoteness variable.

The method most commonly used is the one proposed by Feenstra (2002). It consists in including importer and exporter fixed effects in order to control for the specific country multilateral resistance term, instead of estimating it. The coefficient of the dummies for the importer and the exporter should reflect the multilateral resistance of each country. We will detail this procedure in section 3. Additionally, different specifications and estimations can be found in Micco, Stein and Ordoñez (2003); Baltagi, Egger and Pfaffermayr (2003); Cheng and Wall (2005); Glick and Rose (2001); Ruiz and Vilarrubia (2008); Vicarelli and Benedictis (2004); Fidrmuc (2008); or Henderson and Millimet (2008).

c) Augmenting gravity equation

Concerning the proxy for supply and demand sizes used in the GE, the most common feature is to use GDP of the importer and exporter. However, in some cases GDP per capita is also introduced as a proxy for factor intensities (not only factor endowments of a country).

Additionally, it is commonly accepted that geographical distance may be a poor approximation of all the economic barriers for international trade. To control better these omitted variables, the general gravity equation proposed above has been completed by a wide range of variables depending on the focus of the paper. It is common to include:

- Adjacency. This variable takes value 1 if two countries share a common border. The effect of this variable on trade is expected to be positive.

- Common language: sharing a language should make all transaction easier and costless.

- Colonial links: this effect is introduced by means of a dummy variable. There are two different aspects that may be included: to have had a common colonizer or to have been colonized by the other country in the past. In both cases, the influence is positive. Intuitively, a colonial relationship is prone to reduce cultural differences and costumes between two countries.

- Religion: this variable takes value 1 if both countries share the same religion. It is expected to have a positive effect over trade.

- Remoteness: the (log of) GDP-weighted average distance to all other countries. This variable is a measure of the relative distance between a country and the rest of the world.

- RTA: This effect has been widely studied due to the proliferation of these agreements in the last 20 years. Some articles related with this issue are Hoon Oh and Travis Selmier (2008), Fratianni and Hoon Oh (2007), Martínez-Zarzoso et al. (2003), Greenaway and Milner (2002), Frankel, Stein and Wei (1995), Sapir (2001) or Soloaga and Winters (2001). These authors try to answer the question of the existence of a regional bias to trade, and to discern the trade potential associated with integration. The effect of an RTA over trade is captured by the introduction of dummies. Other specifications (Baldwin et al. 2006) introduce different dummies for the cases in which none, both or only one of the two countries belong to the agreement.

We could mention some other variables that are not so frequently included:

- Technological variables: the influence of these variables on trade is increasing through time. Márquez-Ramos et al. (2005) include them in their model using a different specification for the "hard" and the "soft" investment in infrastructure in a country. Freund and Weinhold (2004) also include technological variables in their specification.

- Access to water: The relationship is again positive, since access to water reduces transport costs. Some specifications of the gravity equation include a "landlocked" or “island” variable to capture a similar effect.

- Area: The bigger the country, the lower the necessity it would have of importing, so the effect of this variable on trade is negative.

-Exchange rate volatility. Frankel and Wei (1995, 1997) evidence a significant negative impact of exchange-rate volatility on trade flows across Asian countries on a cross-section basis, a result found to be strongly robust by Rose (2000), who finds exchange-rate volatility to be a significant and systematic impediment to trade for an extensive sample of countries. Finally, Tenreyro (2006) finds opposite results. Following Santos Silva and Tenreyro (2006), she uses pseudo-maximum likelihood (PML) technique to deal with heteroskedastic biases. To deal with the endogeneity and the measurement error of exchange rate variability she then develops an instrumental-variable (IV) version of the PML estimator. Results indicate that nominal exchange rate variability has no significant impact on trade flows.

3. Estimation methods

It is still not clear which is the new workhorse in the estimation of the gravity equation; every method presents important advantages and disadvantages. For that reason, is becoming a frequent practice in the literature to include several estimation methods using the same database, in order to check which one performs better. We will describe the most important ones, and include them in our estimation.[2] It is also frequent to check this performance with Monte Carlo simulations (Silva and Tenreyro 2006, Martínez-Zarzoso et al. 2007, Martin and Pham 2008, etc.). We detail some of the results in the appendix.

Recently, a new problem is becoming more important in the literature: when a large sample is used, it is frequent to have a lot of zeros in it, but the logarithm of zero is not defined. The literature distinguishes several methods of dealing with that problem. The easiest are truncation (elimination) or censoring methods. However, these methods have not a strong theoretical support and do not guarantee consistent estimates, so they have not been employed frequently in the literature. Alternative solutions are Tobit estimation, Poisson Pseudo Maximum Likelihood estimation, Nonlinear Least Squares (NLS) or Feasible General Least Squares (FGLS).

a) Panel regressions[3]

Until 1990s, it has been a usual practice to estimate gravity equations using cross-section data. However, this type of estimation does not control for heterogeneity among countries. Consequently, results may vary substantially due to the selection of countries, leading to an estimation bias due to omitted variables. To mitigate this problem, researchers have turned towards panel data, that is, cross-section gravity models for several consecutive years (Egger 2000, Rose and van Wincoop 2001, Mátyás 1998, Wall 2000, Egger and Pfaffermayr 2003, 2004; Glick and Rose 2002; Brun, Carrere, and de Melo 2002, Melitz 2007)

Among the advantages of using a panel framework we could cite that it allows us to recognize how the relevant variables evolve through time and to identify the specific time or country effects (institutional, economical, cultural time-invariant or population-invariant factors). Additionally, the problem of potential multicollinearity that sometimes takes place in cross-section estimation is completely solved with panel data.

Fixed effect models assume that the unobserved heterogeneous component in the regression is constant over time. An intuitive way to model it is to include a dummy variable for each country included in the sample except one (to avoid perfect collinearity). Those are the *importer and exporter fixed effects*. Additionally, as Mátyás (1997) points out, there may be a time (business cycle) effect, which is common for every country every year, but it may be different form one year to other. A dummy capturing this *time fixed*

[2] The criteria to compare between different methods are not always the same. The most common are the bias and the expected loss. Martinez-Zarzoso et al. (2008) construct a loss function that consists in the absolute error loss, defined as:

$$L(\beta, \hat{\beta}) = \left|\beta - \hat{\beta}\right|$$

Other functions, such as the squared error loss, are also suggested.

[3] See the appendix for further information

effect is then included.

However, some aspects affecting trade are not fixed along time, which may provoke a bias in the estimation. Consequently, it is common in the literature to include *exporter-yearly and importer-yearly dummies* in the regression. These country dummies absorb all country-specific factors, including those that vary over time.

Furthermore, it is probable that a pair of countries trade with each other due to specific characteristics of those two countries. Then, *country-pair fixed effect* should be included. Again, those effects can be time-varying or time-invariant; hence, two set of different dummies will be required.

Baltagi, Egger and Pfaffermayr (2003) classify the fixed effects into two groups: *main and interaction effects*. The first term makes reference to the usual fixed exporter, importer and time effects, whereas the second includes three types of dummies: one to control for country-pair fixed effects, another to control for exporter specific time-varying effects, and a last one in order to capture the same factors but on the importer's perspective.

The use of fixed effects also presents some **problems**. The most important disadvantage is related with dimension: the introduction of country specific or country pair dummies implies high computational costs. For that reason, Ruiz and Vilarrubia (2007) implement a regression with country triennial dummies, instead of country year dummies. They also make a test with country quinquennial dummies, but they obtain better results with triennial.

Additionally, any explanatory variables that do not vary across time in each country (or pair of countries in the case of country-pair fixed effects) will be perfectly collinear with the fixed effects, and it cannot be included in the model. Then, country-pair fixed effect takes out of the gravity equation some important variables such as land area, common language, common borders or distance, and consequently, the effect of these variables on bilateral trade cannot be estimated.

Some authors have opted to assume that the unobserved component of the regression is distributed *randomly*. The difference between fixed and random effects is given by the correlation of the regressors. Fixed effects allow for correlation between the individual effects and the regressors ($Cov(\alpha_i, x_i)$), whereas random effects impose that correlation to be zero. Orthogonality of the individual effects and the regressors is then required in order to use random effects. In other words, when assuming random effects we are implicitly assuming that the distribution of the unobserved heterogeneous component is distributed as a random variable with given mean and variance. If we had enough evidence to suspect that the correlation is zero, we should employ random effects, because it provides more efficient estimators. However, if we are not sure of that uncorrelation, fixed effects are preferred, since it is an assumption less restrictive: if we assume that the heterogeneity is better modeled with fixed effects and it is not, the equation is still consistent (though not efficient). In the reverse case, consistency cannot be assured.

Fratianni and Hoon Oh (2007) and Kavallari et al. (2008) are two examples of articles including both, fixed and random effects. They compare both models and applies different test in order to choose one of the two models: Breusch-Pagan test, LM test and Hausman test. Their results show that random effect model is preferred.

b) Poisson Pseudo Maximum Likelihood (PPML).

Another problem that arises in the estimation is the "log or not to log" dilemma. It seems that the log-linearization of the error term change the property of this error term and thus conduce to no efficient estimations due to heteroscedasticity. If data are homoscedastic, the variance of the error term is constant and its expected value is constant too. But if data are heteroscedastic, (as usual in trade data) the expected value of the error term is a function of the regressors. Then the conditional distribution of the dependent variable is altered and OLS is not efficient.

Additionally, the expected value of the logarithm of a random variable does not equal the logarithm of its expected value (Jensen's inequality). Consequently, the log-linearization of the gravity equation may introduce a bias in the regression. This point has been remarked several times by Silva and Tenreyro (Tenreyro, 2007; Silva and Tenreyro 2006, 2008). The essential point is that "*the log linearization of the empirical model in the presence of heteroscedasticity leads to inconsistent estimates because the expected value of the logarithm of a random variable depends on higher-order moments of its distribution*" (Silva and Tenreyro, 2006, p. 653). In the standard gravity equation

$$\ln(T_{ij}) = \ln\alpha_0 + \alpha_1 \ln(y_i) + \alpha_2 \ln(y_j) + \alpha_3 \ln(d_{ij}) + \ln(\varepsilon_{ij})$$

The expected value of the log-linearised equation would be:

$$E[\ln T_{ij}] = E[\ln(\alpha_0)] + \alpha_1 E[\ln(Y_i)] + \alpha_2 E[\ln(Y_j)] + \alpha_3 E[\ln(D_{ij})] + E[\ln(\varepsilon_{ij})]$$

Since $\ln E[\varepsilon_{ij}] \neq E[\ln(\varepsilon_{ij})]$, the conditional distribution of T_{ij} is altered and the estimation through OLS will result in misleading estimates.

The **source** of heteroscedasticity in data is not unique: the variance of the error term may vary with the regressors, with the dependent variable or with some other variable that has been omitted. In the gravity equation context, Kalirajan (2008) states that Anderson (1979) included in his theoretical model the *economic distance* between two countries. However, the common practice is to replace this concept by the *geographical distance*. The cost of this simplification is the omission of some important variables related with economic distance but not with geographical. Additionally, these non-included variables may be correlated with the included explanatory variables, so omitting them affects its variance, which will contain an upward bias. Among the aspects that are not easily quantificable, Kalirajan cites the followings: "*large government size, weak and inefficient institution in home and partner countries in terms of, e.g. custom and regulatory environments, port efficiency and e-business and political influences through powerful lobbying by organized interest groups*" (Kalirajan, 2008, p. 1038). He claims that this imprecision in the measurement of distance leads to heteroscedastic error terms. This aspect has been also remarked by Silva and Tenreyro (2006), who point out that probably the variance of the error term is correlated with the countries' GDP and of the measures of distance.

The **solution** proposed by Silva and Tenreyro is to estimate the model in levels, instead of taking logs. OLS cannot be employed in that case, since the equation is non linear. They suggest two alternative methods: Nonlinear Least Squares (NLS) and Poisson

Pseudo Maximum Likelihood (PPML), but finally show PPML as preferred. The reason is that NLS gives more weight to noisier observations, reducing henceforth the efficiency of the estimator.

4. Comparing empirical models and data

a) General model

This paper focuses on the impact of exchange-rate variables on trade flows, and on the comparison of different estimation methods; consequently we do not seek to improve or refine the underlying gravity framework. For that reason the baseline equation used in this paper is a very standard one. It is based on that of Anderson and van Wincoop (2003):

$$lnT_{ij} = \alpha_1 lnGDP_{it} + \alpha_2\ GDP_{jt}\ )+ \alpha_3\ ln\ pop_i + \alpha_4\ lnpop_j + \alpha_5 CONTIG_{ijy} + \alpha_6\ COMLA_{ijt} + \alpha_7\ COMCOL_{ijt} + \alpha_8\ COL_{45} + \alpha_9\ SMCTRY_{ijt} + \alpha_{10}\ lnDIST_{ij} + \beta_i + \beta_j + \beta_t + \beta_{region(i,j,ij)} + \varepsilon ijt$$

The dependent variable is the volume of exports in constant dollars (trade data from the CHELEM-CEPII database, price indexes from the World bank and the IMF). $lnGDP_{it}$ and $lnGDP_{it}$ are the logarithms of real PPP-converted GDPs in each country; ln pop_i and ln pop_j are the logarithms of the total population in each country in millions, and are obtained from CHELEM. Next five variables are dummy variables that takes value one when both countries are contiguous, share a common language or a common colonizer, share a colonial relationship after 1945 or are the same country. $DIST_{ij}$ is a variable representing the geodesic distance between i and j. RER_{ijt} is the real exchange rate, computed using CPI and defined as the relative price of j to i (an increase therefore signals a real depreciation of the currency of country i).

β_i is a vector of fixed effects for the exporting countries. β_j is a vector of fixed effects for the importing countries. β_t is a vector of fixed effects for time (yearly frequency). The $\beta_{region\{i,j,ij\}}$ vector includes dummies for the exporter's and importer's broad regional belonging (MENA, Asia, NMS ...)

Our sample includes 47 countries, of which all the countries of the EU15 and the CEE new European members, and 6 MENA countries (Morocco, Tunisia, Egypt, Turkey, Israel, Algeria). The time sample spans from 1980 to 2003. Hence, the total possible number of observations is 49,726. Due to missing data, the available number of observations is reduced to 34,457.

Because the data are pooled over the cross-country and time dimension, the equation is estimated using the panel within estimator, which implies the use of individual and time fixed effects. Here, the fixed effects are included for country i, country j and time (β_i, β_j and β_t), the pure bilateral dimension ij being caught by the distance variable. Additional fixed effects are also introduced to control for regional features of the countries (summarized in vector $\beta_{region\{i,j,ij\}}$). This vector includes fixed effects for the region to which either the exporter or the importer belongs and bilateral regional fixed effects (i.e. a dummy for each pair of region to which the exporter/importer belong).

b) Results

The empirical model is estimated through three different estimation methods: OLS, panel regression with fixed effect and Panel Poisson methodology.

As expected, the exporter and importer real GDP both increase exports regardless to the estimation methods used. The distance also reduces exports though the elasticity is lower when using Poisson techniques. The estimated coefficients for GDP are near to 1, which is the expected order of magnitude, and the distance coefficient is also near to minus 1. Other gravity variables are also highly significant, and with most of them proximity (either in history or in space) tends to increase exports. The only exception is with contiguity, which unexpectedly bears a negative sign when the gravity equation is estimated with panel with fixed effects while it displays the positive expected sign when Poisson is used. However, this variable is potentially collinear to the adjacency variable (close countries have a higher probability to share the same language), which could explain the sign of the estimate. The techniques of estimation seem to affect the magnitude of the parameters but not the sign for the other gravity variables. In particular, the impact of distance is found to be smaller under Poisson as in Martinez-Zarzoso et al. (2007). Unlike these authors, we do not appreciate important asymmetries in the coefficients of importer's and exporter's GDP using Poisson.

To have a first idea of the goodness of fit, we plot predicted over real value of exports for different techniques and compare the dispersions of the results. Graphics can be found in the appendix.

5. Impact of EMU on exports

a) Model

To assess the impact of exchange-rate variables on trade flows, we modify the previous equation, including some additional variables:

$$\ln T_{ij} = \alpha_1 \ln(GDP_{it}\ GDP_{jt}) + \alpha_2 \ln pop_i + \alpha_3 \ln pop_j + \alpha_4 CONTIG_{ijy} + \alpha_5\ COMLA_{ijt} + \alpha_6\ COMCOL_{ijt} + \alpha_7\ COL_{45} + \alpha_8\ SMCTRY_{ijt} + \alpha_9 \ln DIST_{ij} + \alpha_{10} \ln RER_{ijt} + \alpha_{11}\ VOL_{ijt} + \alpha_{12} RTAone + \alpha_{13}\ RTAboth + \alpha_{14}\ UEMone + \alpha_{15}\ UEMboth + \beta_i + \beta_j + \beta_t + \beta_{region(i,j,ij)} + \varepsilon ijt$$

RER_{ijt} is the real exchange rate, computed using CPI and defined as the relative price of j to i (an increase therefore signals a real depreciation of the currency of country i).

VOL_{ijt} is a measure of volatility. This measure is one of the less obvious to build, as can be seen from the large number of volatility proxies that are available for the exchange rate. First of all, a large part of the financial literature highlights the fact that, as long as agents are information-seeking, only the unexpected part of exchange-rate volatility can have potential consequences on economic decisions. This is the reason why this literature has developed econometric models of the exchange-rate volatility (see e.g. ARCH models - and their various derivatives - for exchange rate series) aiming at extracting information from volatility series, and therefore allowing build unexpected volatility series.

In the longer run, exchange-rate are often described as following a random walk, and their standard deviation (or their coefficient of variation) is often enough to describe their volatility. While this might be true for nominal exchange rates, it is less relevant for real exchange rates, which are driven by fundamentals. In order to correctly measure their volatility, de-meaning is usually necessary, and a better measure of volatility is therefore the standard deviation of the rate of change of exchange-rate series.

We chose to use this last definition of volatility, applying it alternatively to monthly nominal and real exchange rates[4].

The definition of exchange rate volatility is therefore the following:

$$\text{VOL}=\sqrt{\text{Var}(\ln \text{ER}_{\text{ij}\,\tau}-\ln ER_{\text{ij},\tau\text{-1}})_{\{\tau=1\to 12\}}}$$

Where $ER_{ij\tau}$ is the exchange rate, either nominal or CPI-deflated, and τ is monthly. Hence, we compute the volatility of the monthly exchange rate for a given year.

The impact of real exchange-rate changes on trade is now being quite well identified: a real appreciation usually has a deleterious impact on exports through a demand effect (lower competitiveness) or a supply effect (higher profitability of the traded goods sector compared to the non-traded goods sector).

The link between exchange-rate volatility and trade flows is less clear. According to McKenzie (1999), the elasticity of trade flows to exchange-rate volatility can be either positive or negative, and the results depend on the precise measure of volatility, on the estimation technique and on the sectors and countries concerned. Moreover, the impact of exchange-rate volatility might differ according to the countries under study: Sauer and Bohara (2001) show that exchange-rate volatility has a negative impact on African and Latin American exports, a non-significant impact on Asian exports and on developed countries exports.

Finally, a set of dummies is introduced. UEMone and UEMboth are two variables that take value one when one or both countries respectively belong to the EMU, which allow us to assess the effect of the EMU on non EU countries exports. Analogously, RTAone and RTAboth capture the effect of belonging to a regional trade agreement.

b) Results

Gains from anchoring to one money are assumed to be larger when the elasticity of trade to exchange rate volatility is higher, and this assumption allows investigating the potential gains of joining the euro area. Our database includes countries from different regions (MENA countries, Asian countries, New Member States in the European Union, other developed countries). By including dummies for trade and monetary agreements, we will try to estimate how a fixed peg is affecting Eurozone's trade with its main trading partners. We first study the impact of real exchange rate and volatility of the exchange rate on trade flows. Gains from anchoring are assumed to be larger when the elasticity of trade to exchange rate volatility is higher. Our database include countries from different regions (MENA countries, Asian countries, New Member States in the European Union, other developed countries). By including dummies for trade and monetary agreements, we will try to estimate how a fixed peg had affected third countries exports to the EMU and to other zones.

[4] Notice that working on shorter-run data would call for the use of ARCH models. However, ARCH effects are usually shown to be less prevalent in the longer run (from the quarter to the year).

When studying the impact of real exchange rate and volatility on exports (Table B2), the real exchange rate has the expected positive sign but elasticities differ from an estimation technique to another. In particular when individual fixed effect are used the elasticity is larger a 10% depreciation leads to a 3% increase in bilateral exports while the effects is half lower when controlling for country pair fixed effects or using Poisson. This is a rather sensible price-elasticity estimate (working on the G7 countries, and relying on time-series econometrics, Hooper et al., 1998, find the long-run price-elasticity of exports to be ranging between .2 and 1.6).

The volatility of the exchange rate also has a detrimental effect on exports, which is significant at the 1% level. Here, a 10 point increase in volatility leads to a decrease between 7 and 8 % in exports according to panel estimations and more than 30% acording to Poisson estimates.

Summing-up the whole-sample estimates, it appears that nominal or real exchange rate volatility is unambiguously detrimental to trade. As in Westerlund and Wilhelmson (2006) we found that the Poisson ML estimates are typically larger than their OLS counterparts.

Concerning the effect of RTA (Table B3), these agreements increase exports in all regresions when the exporter and the importer are members. The effect is also positive when only the importer or the exporter is a member of a RTA but this result is less robust in Poisson estimations. Concerning the effect of the EMU, our results tend to show that the effects on exports are small or negative when significant. Poisson estimations support in general the most pessimistic views.

When we take into account the fact that the member of the Euro zone is the exporter or the importer (Table B4), our result do not support any diversion effect. On the opposite EMU seems to strengthen both exports and imports to third countries. Though in this model, export among EMU members appears negative. Poisson estimates indicate that both RTA and EMU have diversion effects since exporting to one member will reduce export of the third country exporter while fixed effects estimations drive opposite conclusions.

Our results are not so enthusiastic as previous results from Rose (2000) or from Micco et al. (2003) concerning the effect of EMU on trade among the members. Though these authors do not control for the exchange rate volatility, and Rose uses a cross section among a very large sample while Micco et al. (2003) use panel with country pair fixed effects for only 22 developed countries. These differences may explain the difference in the results. Micco et al. (2003) also found that EMU could have boosted trade with non-members.

6. Concluding remarks

The choice of an exchange rate regime, the possibility to peg or not to peg to the Euro and the effect the Euro could have on trade among members or with third countries or, lastly, between these third countries are puzzling questions.

First of all, our study confirms that the estimation technique is not neutral to study the effect of exchange-rate regimes – defined by the level of and the volatility of the (real) exchange rate – on exports, though it does not have so much importance for a basic model of trade flows. Different techniques lead to divergent results when the impact of EMU is studied. All in all, our results do not show strong diversion effects of the EMU.

This work could be extended in various directions. First, to conclude seriously about the appropriate estimations techniques some complementary tests should be performed or Monte Carlo simulations could also be used. Secondly, concerning the effect of the Euro on other countries exports, the period under study should be longer to capture the period after the Euro. Some asymmetries among members should be investigated and the effect of the Euro for trade among third countries could be an interesting issue.

7. References

Anderson, J. and Eric van Wincoop. 2003. Gravity with Gravitas: A Solution to the Border Puzzle, *American Economic Review*, 93: 170-192.

Anderson, J. E. 1979. "A theoretical foundation for the gravity equation". *American Economic Review*, 69: 106-116.

Baier, S., and Bergstrand, J. 2006. "Bonus vetus OLS: A simple approach for addressing the border-puzzle and other gravity issues', mimeo, March 2006

Baldwin, Richard and Virginia DiNino. 2006. "Euros and zeros: The common currency effect on trade in new goods", *HEI Working Paper* 21/2006

Baldwin et al. 2008. "Study on the impact of the Euro on Trade and FDI", *European Comission,* Economic Paper 321

Bergstrand, Jeffrey H. 1990. "The Heckscher-Ohlin-Samuelson Model, the Linder Hypothesis and the Determinants of Bilateral Intra-industry Trade." Economic Journal 100: 1216-29.

Brun, Jean-François, Céline Carrère, Patrick Guillaumont and Jaime de Melo. 2002. "Has Distance Died? Evidence from a Panel Gravity Model," *CERDI* WP nº 2002/15

Burger, Martijn J., Frank G. van Oort and Gert-Jan M. Linders. 2009. "On the Specification of the Gravity Model of Trade: Zeros, Excess Zeros and Zero-Inflated Estimation", Forthcoming in *Spatial Economic Analysis*. Working paper version: ERIM Research Report 2009-003-ORG.

Cafiso, Gianluca. 2008. "The Euro's influence upon trade: Rose effect versus Border effect", *European Central Bank*, Working Paper 941.

Clark, Peter B., 1973, Uncertainty, Exchange Risk, and the Level of International Trade, *Western Economic Journal*, September, pp. 302-13.

Deardorff, Alan V. 1998. "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?" In The Regionalization of the World Economy, edited by Jeffrey A. Frankel. Chicago: Univ. Ghicago Press (for NBER.

De Benedictis, Lucas and Claudio Vicarelli. 2005. "Trade Potentials in Gravity Panel Data Models," *Topics in Economic Analysis and Policy,* Berkeley Electronic Press, 5(1): 1386-1386.

Dixit, A.; Stiglitz, J. 1977. Monopolistic competition and optimum product diversity; *American Economic Review*, 67 (3), 297-308.

Egger, Peter. 2000. "A Note on the Proper Econometric Specification of the Gravity Equation," *WIFO Working Papers* 108.

Egger, Peter, and Michael Pfaffermayr. 2003. The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects. *Empirical*

Economics, 28

Egger, Peter and Michael Pfaffermayr. 2004. "Distance, Trade and FDI: A SUR Hausman-Taylor Approach", *Journal of Applied Econometrics* 19 (2): 227-246

Evenett, Simon J. and Wolfgang Keller. 2002. "On Theories Explaining the Success of the Gravity Equation". *The Journal of Political Econom*y 110(2): 281-316.

Fratianni, Michele. 2007. "The gravity equation in international trade". *Handbook of international trade*, 2nd edition, Oxford University Press, Forthcoming

Fratianni, Michele and Chang Hoon Oh. 2007. "On the relationship between RTA expansion and Openness" Kelley School of Business.

Feenstra, Robert. 2002. "Border effects and the gravity equation. Consistent methods for estimation", *Scottish Journal of Political Economy*, 49(5): 491-506.

Freund, C. L. and Weinhold, D. 2004. The effect of the Internet on international trade*, Journal of International Economics 62, 171-189.*

Frankel, Jeffrey A., Ernesto Stein, Shang-Jin Wei. 1995. Trading blocs and the Americas: The natural, the unnatural, and the super-natural *Journal of Development Economics*, 47: 61-95.

Frankel, Jeffrey A., Ernesto Stein, Shang-Jin Wei, and Institute for International Economics. 1997. "Regional Trading Blocs in the World Economic System". *Washington DC: Institute for International Economics.*

Feenstra, Robert, James Markusen and Andrew Rose. 2001. "Using gravity equation to differentiate among alternative theories of trade" *Canadian Journal of Economics*, 34 (2)

Gil-Pareja, Salvador, Rafael Llorca-Vivero, José Martínez-Serrano, Josep Oliver-Alonsol. 2005. "The Border Effect in Spain", *The World Economy*, 28 (11):1617-1631

Gil-Pareja, Salvador, Rafael Llorca-Vivero and José Martínez-Serrano. 2008. " Trade effects of monetary agreements: Evidence for OECD countries", *European Economic Review*, 52 (4):733-755

Gil-Pareja, Salvador, Rafael Llorca-Vivero, José Martínez-Serrano.2009. "Continental bias in trade", *Fundación de las Cajas de Ahorros,* Documento de trabajo nº 440/2009

Glick, Reuven and Andrew Rose. 2002. "Does a currency union affect trade? The time-series evidence," *European Economic Review*, 46(6): 1125-1151.

Head, Keith and Thierry Mayer, 2000. "Non-Europe: The magnitude and causes of market fragmentation in the EU," *Review of World Economics*, 127(2): 284-314.

Helpman, Elhanan and Krugman, Paul. 1985. "Market Structure and Foreign Trade". Cambridge, MA: MIT Press.

Henderson, Daniel and Daniel Millimet. 2008. “Is gravity linear?”, *Journal of Applied Economics* 23: 137–172

Hooper, Peter, and Steven Kohlhagen, 1978, The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade, *Journal of International Economics*, 8: 483-511.

Kavallari, A.; Maas, S. and Schmitz, P.M., 2008. "Explaining German imports of olive oil: evidence from a gravity model," *European Association of Agricultural Economists*; International Congress, August 26-29, 2008, Ghent, Belgium 44217

Kang, Heejoon and Michele Fratianni. 2006. "International Trade Efficiency, the Gravity Equation, and the Stochastic Frontier", *Kelley School of Business*, WP 2006-08

Lahrèche-Révil, Amina and Juliette Milgram, 2006. "Exchange-rate policies and trade in the MENA countries," ThE Papers 06/07,*University of Granada*.

Leamer, Edward and Robert. 1971. *Journal of International Economics*, 1(3): 359-361

Stern Quantitative international economics:

Linders, Gert-Jand and Henri L.F. de Groot. 2006. "Estimation of the gravity equation in the presence of zero flows", *Tinbergen Institute Discussion Paper*, 072/3

Manning, W.G. and Mullahy. 2001. "Estimating Log Models: To Transform or Not to Transform?", *Journal of Health Economics* 20:461-494

Martin and Pham. 2008, "Estimating the Gravity Equation when Zero Trade Flows are Frequent", MPRA Paper No. 9453

Márquez-Ramos, Laura; Inmaculada Martínez-Zarzoso and Celestino Suárez-Burguet. 2007. "The Role of Distance in Gravity Regressions: Is There Really a Missing Globalisation Puzzle?", *The B.E. Journal of Economic Analysis & Policy*, 7(1)

Martinez-Zarzoso Inmaculada and F. Nowak-Lehman. 2003. Augmented Gravity Model: An Empirical Application to Mercosur-European Union Trade Flows, *Journal of Applied Economics*, 6 (2): 291-316.

Martínez Zarzoso, Inmaculada and Laura Márquez Ramos. 2005. "International Trade, Technological Innovation And Income: A Gravity Model Approach," Instituto Valenciano de Investigaciones Económicas, S.A, Working Papers. Serie EC 2005-15.

Martínez-Zarzoso, Inmaculada; Felicitas Nowak-Lehmann D. and Sebastian Vollmer et al. 2007. "The log of gravity revisited". *Center for European, Governance and Economic Development Research.* Discussion Papers 64.

Melitz, Marc. 2003. "The impact of trade on intraindustry reallocations and aggregate industry productivity" *Econometrica* 71, 1695--1725

Melitz, Marc. 2007. "North, South and Distance in the gravity equation", *European Economic Review* 51: 971--991

Melitz, Marc and Giancarlo Ottaviano. 2008. "Market Size, Trade and Productivity", *Review of Economic Studies* (75): 295—316

Alejandro Micco, Alejandro, Ernesto Stein and Guillermo Ordoñez. 2003. "The currency union effect on trade: early evidence from EMU," *Economic Policy*, 18(37), pages 315-356.

Rose, Andrew K. 2000. "One Money, One Market: The Effect of Common Currencies on Trade" *Economic Policy*, 15(30): 9.

Rose, Andrew and Eric van Wincoop. 2001. "National Money as a Barrier to International Trade: The Real Case for Currency Union" *American Economic Review,* 91(2): 386-390

Sapir, André. 2001. "Domino effects in Western European Regional Trade" *European Journal of Political Economy,* 17: 377-388

Serlenga, Laura and Yongcheol Shin. 2007. "Gravity models of intra-EU trade: application of the CCEP-HT estimation in heterogeneous panels with unobserved common time-specific factors" *Journal of Applied Economics 22:* 361-381

Silva, J. M. C. S. and Silvana Tenreyro. 2006. "The Log of Gravity" *Review of Economics & Statistics*, 88(4): 641-658.

Silva, J. M. C. S. and Silvana Tenreyro. 2008. "Trading Partners and Trading Volume: Implementing the Helpman-Melitz-Rubinstein Model Empirically" University of Essex, Discussion Paper Series 662.

Soloaga, I. and Winters, A. 2001. "Regionalism in the nineties: what effect on trade?" *North American Journal of Economics and Finance*, 12, 1-29.

Tenreyro, Silvana. 2007. "On the Trade Impact of Nominal Exchange Rate Volatility" *Journal of Development Economics*, 82(2): 485-508.

Wei, Shang-Jin. 1996. "Intra-National Versus International Trade: How Stubborn Are Nations in Global Integration?" *National Bureau of Economic Research* WP 5531.

Westerlund, Joakim and Fredrik Wilhelmsson. 2006. "Estimating the gravity model without gravity using panel data" Nationalekonomiska institutionen Department of Economics, WP

Wolf, H. C. 1997. "Patterns of Intra- and Inter-State Trade". *National Bureau of Economic Research* Working Paper 5939.

Wong, Wei-Kang. 2008. "Comparing the fit of the gravity model for different cross-border flows", *Economic letters* 99: 474-477

8. Appendix

A. Literature review

Table A1. Articles using fixed effects, random effects or both in the regression

Article	Effects included	Disaggregation level	M, X or T
Matyas (1997)	Fixed importer, exporter and time effects	11 countries, 1982-1994	Exports
Rose and van Wincoop (2001)	Time effects, country specific fixed effects	Data at five-year intervals between 1970 and 1995 covering almost 200 countries	Bilateral trade
Glick and Rose (2002)	- Country pair fixed effects - They impose the restriction that the country-pair effects are symmetric (i.e., αij = αji).	Panel data set covering 217 countries from 1948 through 1997	Real bilateral trade
Baltagi, Egger and Pfaffermayr (2003)	- Fixed importer, exporter and time effects - Country pair fixed effects - Importer-time effect - Exporter time effect for exporter specific time variant effects	Panel of bilateral trade between the triad (EU15, USA and Japan) economies and their 57 most important trading partners over the period 1986–1997	Real bilateral exports
Micco, Stein and Ordoñez (2003)	- Time effects - Country pair fixed effects - No individual effects	22 developed countries; 1992 - 2002	Bilateral trade (sum of imports and exports
Vicarelli and Benedictis (2004)	- Bilateral (country-pair) fixed effects - Dynamic effects (Arellano and Bond estimator)	Export equation for each of former 11 Eurozone countries to 32 importer countries; period 1991-2000.	Exports
Cheng and Wall (2005)	- Country-pair fixed effects - Time effects	Balanced panel with 3,188 observations (797 unidirectional country pairs in each of four years: 1982, 1987, 1992, and 1997	Real exports
Fratianni and Hoon Oh (2007)	- Country pair and time fixed effects - Random effects	143 countries for the period 1980-2003.	Real bilateral imports
Cafiso (2008)	Country pair and time fixed effects	Manufacture export between 24 OECD countries (sectors 15-37, ISIC Rev. 3); 1993-2003	Exports
Fidrmuc (2008)	Country pair, time effects	19 OECD countries between 1980 and 2002.	Bilateral trade flows (average of exports and imports)
Henderson and Millimet (2008)	Country specific, country pair fixed effects	1993 and 1997; US data. 25 two-digit SIC industries;	Nominal value of exports
Hoon Oh and Travis Selmier II (2008)	- Time-invariant country-pair fixed effects - Time-invariant country-pair random effects	1980–2001, 10,520 observations for 859 bilateral pairs	Imports
Kavallari et al. (2008)	Random effects	German imports of olive oil from 14 exporting countries; 1995-2006.	Imports
Ruiz and Vilarrubia (2008)	- Fixed importer, exporter and time effects - Exporter-period and importer-period dummies (annual, triennial and quinquennial)	205 countries from 1948 to 2005 (regression over the top 100 exporters)	Bilateral trade

Table A2. Alternative estimation methods in the literature

Article	Countries and years	Estimation methods (preferred)	Disaggregation level	M, X or T	Simulation studies
Silva and Tenreyro (2006)	Cross section of 136 countries in 1990 (18,360 observations)	- **PPML** , NLS , GPML, OLS, ET-tobit , OLS(*y* >0,.5) OLS (y+1)	Aggregated data -Dummy for FTAs	Bilateral trade flows	- PPML, NLS, GPML OLS; OLS(*y* + 1); truncated OLS ET-tobit. - Four different patterns of heteroscedasticity
Martínez-Zarzoso (2007)	3 datasets: 1) 180 countries; 1980-2000 2) 47 countries; 1980-1999 3) 65 countries; data for every 5 years over 1980-1999.	- **FGLS**,Gamma, Poisson, Heckman	Aggregated data	Exports	- OLS, NLS, Gamma Pseudo Maximum Likelihood (GPML), PPML and FGLS
Siliverstov and Schumacher (2007)	1988 to 1990; 22 OECD countries	OLS, PQML	Disaggregated data: 25 three-digit ISIC Rev.2 industries and the manufacturing as a whole	Average annual trade flows	No
Westerlund and Wilhelmsson (2007)	1992-2002; import data for EU and other developed countries (35256 observations)	OLS, fixed effect PML	Aggregated data	Nominal imports	- OLS, truncated OLS, OLS (y+1), PPML - Two patterns of heteroscedasticity
Helpman, Melitz and Rubinstein (2008)	158 countries, 1970-1997	**HMR** (Probit and OLS), NLS, semiparametric, non-parametric	Aggregated data	Exports	No
Martin and Pham (2008)	Dataset from S&T (2006): cross section of 136 countries in 1990 (18,360 observations)	- Truncated OLS, ET-Tobit, PPML, Heckman ML, Heckman 2SLS	Aggregated data	Bilateral trade	- Truncated OLS, OLS (y+1), truncated NLS, censored NLS, GPML, PPML, truncated PPML, ET Tobit, Poisson-Tobit,Heckman
Silva and Tenreyro (2008)	158 countries; 1986 (cross-section)	HMR (Probit and OLS), NLS, semiparametric, non-parametric, GPML	Aggregated data	Exports	No
Burger et al. (2009)	138 countries 1996-2000	OLS, Poisson and modified Poisson (negative binomial, zero-inflate: ZIPPML, NBPPML)	Aggregated data	Average of yearly exports	No

B. Estimation results

Table B1. Baseline model

	OLS	**Panel fe**	**Poisson**	**Poisson fe**
Log of exporter real GDP	0.769*** [0.037]	0.826*** [0.022]	0.699*** [0.001]	0.699*** [0.001]
Log of importer real GDP	0.577*** [0.037]	0.831*** [0.022]	0.546*** [0.001]	0.546*** [0.001]
Contiguity	-0.333*** [0.034]	0.000 [0.000]	0.454*** [0.001]	0.454*** [0.001]
Common Language	0.491*** [0.024]	0.000 [0.000]	0.226*** [0.000]	0.226*** [0.000]
Colony	0.349*** [0.040]	0.000 [0.000]	-0.137*** [0.001]	-0.137*** [0.001]
Common Colony	0.642*** [0.048]	0.000 [0.000]	-0.273*** [0.001]	-0.273*** [0.001]
Colony after 1945	0.666*** [0.062]	0.000 [0.000]	0.244*** [0.001]	0.244*** [0.001]
Same Country	0.692*** [0.054]	-0.390*** [0.125]	0.170*** [0.001]	0.170*** [0.001]
Log of Distance	-1.248*** [0.009]	0.000 [0.000]	-0.713*** [0.000]	-0.713*** [0.000]
Constant	-23.150*** [1.321]	37.515*** [1.135]	21.970*** [0.035]	
Individual fixed effects Time effects Country pair fixed effects	Yes Yes No	No No Yes	Yes Yes No	Yes Yes No
Observations	38643	38643	41950	41950
R-squared	0.836	0.180	0.9297	
Notes: Standard errors in brackets. ** Significant at 5%; *** Significant at 1%.				

Table B2. Effects of real exchange rate and volatility on exports

	OLS	Panel fe	Poisson	Poisson fe
Log of exporter real GDP	0.897***	1.040***	0.936***	0.936***
	[0.045]	[0.027]	[0.158]	[0.001]
Log of importer real GDP	0.797***	0.951***	0.681***	0.681***
	[0.045]	[0.027]	[0.081]	[0.001]
Contiguity	-0.388***	0.000	0.384***	0.384***
	[0.034]	[0.000]	[0.143]	[0.001]
Common Language	0.540***	0.000	0.259**	0.259***
	[0.024]	[0.000]	[0.130]	[0.001]
Colony	0.349***	0.000	-0.103	-0.103***
	[0.040]	[0.000]	[0.147]	[0.001]
Common Colony	0.368***	0.000	-0.316	-0.316***
	[0.050]	[0.000]	[0.267]	[0.002]
Colony after 1945	0.748***	0.000	0.345	0.345***
	[0.063]	[0.000]	[0.272]	[0.001]
Same Country	0.914***	-0.380***	0.301*	0.301***
	[0.055]	[0.124]	[0.168]	[0.001]
Log of Distance	-1.230***	0.000	-0.724***	-0.724***
	[0.009]	[0.000]	[0.041]	[0.000]
Log of RERij	0.337***	0.148***	0.136**	0.136***
	[0.023]	[0.014]	[0.055]	[0.001]
NER Volatility	-0.743***	-0.850***	-3.395***	-3.395***
	[0.144]	[0.119]	[0.786]	[0.009]
Constant	-31.951***	-46.702***	-31.189***	
	[1.600]	[1.398]	[4.663]	
Individual fixed effects	Yes	No	Yes	Yes
Time effects	Yes	No	Yes	Yes
Country pair fixed effects	No	Yes	No	No
Observations	34893	34893	35324	35324
R-squared	0.838	0.194	0.9314	

Notes: Robust standard errors in brackets. ** Significant at 5%; *** Significant at 1%.

Table B3. Effect of RTAs on exports

	OLS	Panel fe	Poisson	Poisson fe
Log of exporter real GDP	0.881*** [0.045]	1.071*** [0.028]	0.810*** [0.036]	0.969*** [0.001]
Log of importer real GDP	0.774*** [0.045]	0.979*** [0.028]	0.826*** [0.047]	0.701*** [0.001]
Contiguity	-0.372*** [0.034]	0.000 [0.000]	0.395** [0.200]	0.352*** [0.001]
Common Language	0.538*** [0.024]	0.000 [0.000]	0.352** [0.150]	0.260*** [0.001]
Colony	0.354*** [0.040]	0.000 [0.000]	-0.033 [0.153]	0.011*** [0.001]
Common Colony	0.387*** [0.050]	0.000 [0.000]	0.584 [0.538]	-0.336*** [0.002]
Colony after 1945	0.734*** [0.063]	0.000 [0.000]	0.234 [0.284]	0.299*** [0.001]
Same Country	0.911*** [0.055]	-0.378*** [0.124]	0.399 [0.278]	0.363*** [0.001]
Log of Distance	-1.225*** [0.010]	0.000 [0.000]	-0.633*** [0.069]	-0.632*** [0.000]
Log of RERij	0.339*** [0.023]	0.145*** [0.014]	-0.024 [0.076]	0.128*** [0.001]
NER Volatility	-0.692*** [0.144]	-0.729*** [0.119]	-3.421*** [1.163]	-2.988*** [0.009]
One partner has RTA	0.260*** [0.021]	0.092*** [0.019]	0.148 [0.135]	-0.001 [0.001]
Both partners have RTA	0.143*** [0.021]	0.294*** [0.022]	0.223* [0.118]	0.447*** [0.000]
One partner in EMU	0.187*** [0.027]	0.002 [0.024]	-0.301*** [0.076]	-0.036*** [0.001]
Both partners in EMU	-0.345*** [0.059]	-0.049 [0.052]	0.173 [0.118]	0.033*** [0.001]
Constant	-31.019*** [1.624]	-48.279*** [1.423]	-31.564*** [2.407]	
Observations	34893	34893	35324	35324
Individual fixed effects	Yes	No	Yes	Yes
Time effects	Yes	No	Yes	Yes
Country pair fixed effects	No	Yes	No	No
R-squared	0.840	0.199	0.9347	

Notes: Robust standard errors in brackets. ** Significant at 5%; *** Significant at 1%.

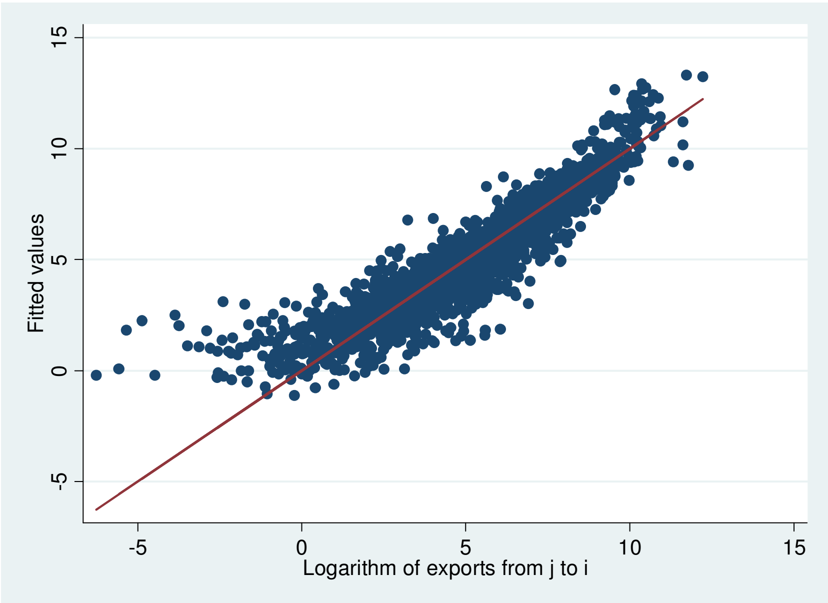
Table B4. RTA and EMU diversion effects

	OLS	Panel fe	Poisson	Poisson fe
Log of exporter real GDP	0.882***	1.070***	0.971***	0.971***
	[0.045]	[0.028]	[0.001]	[0.001]
Log of importer real GDP	0.773***	0.980***	0.699***	0.699***
	[0.045]	[0.028]	[0.001]	[0.001]
Contiguity	-0.372***	0.000	0.352***	0.352***
	[0.034]	[0.000]	[0.001]	[0.001]
Common Language	0.538***	0.000	0.260***	0.260***
	[0.024]	[0.000]	[0.001]	[0.001]
Colony	0.354***	0.000	0.011***	0.011***
	[0.040]	[0.000]	[0.001]	[0.001]
Common Colony	0.387***	0.000	-0.336***	-0.336***
	[0.050]	[0.000]	[0.002]	[0.002]
Colony after 1945	0.734***	0.000	0.299***	0.299***
	[0.063]	[0.000]	[0.001]	[0.001]
Same Country	0.911***	-0.377***	0.363***	0.363***
	[0.055]	[0.124]	[0.001]	[0.001]
Log of Distance	-1.225***	0.000	-0.632***	-0.632***
	[0.010]	[0.000]	[0.000]	[0.000]
Log of RERij	0.339***	0.148***	0.125***	0.125***
	[0.023]	[0.014]	[0.001]	[0.001]
NER Volatility	-0.692***	-0.728***	-2.986***	-2.986***
	[0.144]	[0.119]	[0.009]	[0.009]
One partner has RTA	0.260***	0.094***	-0.001	-0.001
	[0.021]	[0.019]	[0.001]	[0.001]
Both partners have RTA	0.143***	0.297***	0.447***	0.447***
	[0.021]	[0.022]	[0.000]	[0.000]
EMUimp	0.181***	-0.069**	-0.047***	-0.047***
	[0.035]	[0.029]	[0.001]	[0.001]
EMUexp	0.193***	0.073**	-0.027***	-0.027***
	[0.035]	[0.029]	[0.001]	[0.001]
Both partners in EMU	-0.158***	-0.047	-0.003***	-0.003***
	[0.061]	[0.051]	[0.001]	[0.001]
Constant	-31.020***	-48.289***	-33.049***	
	[1.624]	[1.423]	[0.044]	
Individual fixed effects	Yes	No	Yes	Yes
Time effects	Yes	No	Yes	Yes
Country pair fixed effects	No	Yes	No	No
Observations	34893	34893	35324	35324
R-squared	0.840	0.200	0.9347	

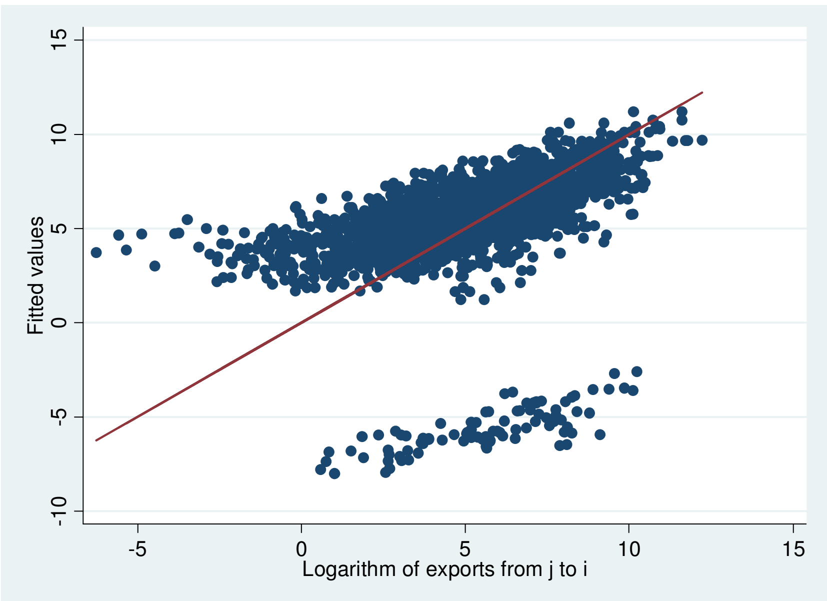
Notes: Robust standard errors in brackets. ** Significant at 5%; *** Significant at 1%. EMUimp takes value one when the importer belongs to EMU and EMUexp when the exporter belongs to EMU.

C. Cross-validation for the different estimation methods in year 2002

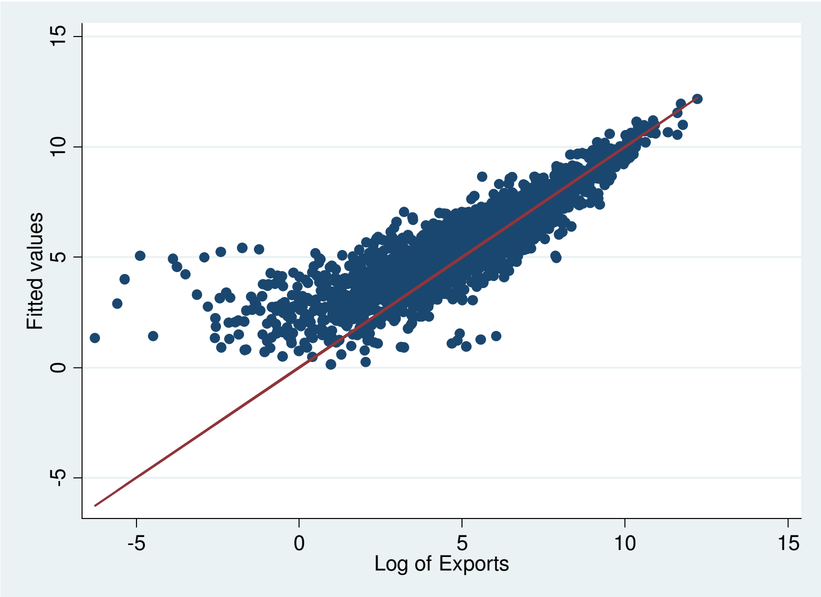
C1. Cross- validation for OLS regression. Importer, exporter and time dummies



C2. Cross- validation for Panel regression. Country pair and time effects



C3. Cross-validation for Poisson regression



C4. Cross-validation for Poisson regression with fixed effects