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.

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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 three dimension (i, j, t) 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 applied to 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 has not been clearly answered until now. The sensitiveness of exports 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.

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-Pareja et al. (2008). Hence, 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 nominal 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 baseline model and the data are presented. Section 5 compares three new specifications with the baseline in order to assess the impact of exchange rate variables and EMU on trade. 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

2.1. Theoretical 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 put 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, and Helpman et al. (2008) in the context of heterogeneity of firms. It seems that the Heckser-Ohlin 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). This model is overall interesting to the extent that the discussion of the multilateral resistance may matter for the heteroscedasticity considerations. For instance, as GDP increases, remote countries will tend to diversify their production, (since their trade costs are higher), becoming less open to trade. However, if they are located near to other countries, their specialization is likely to be higher, and trade flows in this case will become more frequent. This divergence in trade patterns can thus lead to higher variance associated to higher levels of income, depending on the multilateral trade barriers in each case. As it is well-known, Anderson and van Wincoop (2003) argued that *"remoteness" variable related to distance to all bilateral partners was a key variable for gravity models.*

Representative agents in their model are countries that export and import goods. They assume that goods are differentiated by place of origin; that each country is specialized in the production of only one good and that 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.

Exporter countries are specialized in the production of one good, which can be exported at price p_{ij} or consumed inside the country at price p_i. The supply of each good is fixed. Importer countries maximize their utility function subject to a budget constraint (income should equal expenditure). The representative individual is the consumer, consumes domestic goods in proportion (1-β_i) and imported goods (from country j) in proportion β_i.

The utility function of the representative consumer is stated as:

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

where c_{ij} is the consumption of importer j in goods from exporter i and σ is the elasticity of substitution between goods from different countries and β is a positive distribution parameter that denotes the share of importer j in country i's consumption. Consumer's constraint is given by:

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

where y_j is the nominal income of importer j, proxied by its GDP. p_{ij} is the c.i.f. import price of exporter i's goods for importer j consumers and x_{ij} is the nominal value of exports from i to j.

Prices differ among countries due to trade costs that are not directly observable. Trade costs are modeled as Krugman's iceberg costs, which implies that t_{ij} units of good from export country i need to be shipped in order for one unit to reach country j. Given the exporter's supply price, p_i, the export price would be $p_{ij} = p_i t_{ij}$. This means that for each unit of good shipped from i to j the trade cost would be $t_{ij} - 1$ (in terms of the good i lost to shipping). The exporter passes on these trade costs to the importer. It should be noted that if $i = j$, then $t_{ij} = 1$ and $p_{ij} = p_i$.

Solving the maximization problem of consumer j , the nominal demand of country j for goods from country i is obtained as:

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

P_j is a function of j's full set of bilateral trade resistance terms:

$$P_j = \left[\sum_i \left(\beta_i p_i t_{ij} \right)^{1-\sigma} \right]^{1/(1-\sigma)} \qquad (4)$$

This is the key innovation introduced by Anderson and van Wincoop (2003). They claim that bilateral trade costs are not the only factor affecting trade, but also trade costs of each country with all others. Hence, three components of trade resistance can be identified: bilateral trade barriers between region i and j, (t_{ij}); i's resistance to trade with other countries (P_i) and j's resistance to trade with other countries (P_j).

Equating the nominal demand in country j and the supply in country i:

$$y_i = \sum_j x_{ij} = \sum_j (\beta_i t_{ij} p_i / P_j)^{(1-\sigma)} y_j = (\beta_i p_i)^{1-\sigma} \sum_j (t_{ij} / P_j)^{(1-\sigma)} y_j \qquad (5)$$

Scaled prices, $\{ \beta_i p_i \}$, are solved from this equation and substituted into (3).

Defining $y^w \equiv \sum_j y_j$ as the world income and income shares by $\theta_j \equiv y_j / y^W$, equation (3) turns into:

$$x_{ij} = \frac{y_i y_j}{y^w} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \quad (6)$$

where $\prod_i$ is an abbreviator for country i's ideal price index:

$$\Pi_i \equiv (\sum_j (t_{ij} / P_j)^{1-\sigma} \theta_j)^{1/(1-\sigma)} \quad (7)$$

Once $\{ \beta_i p_i \}$ are substituted into (4), P_j can be expressed as:

$$P_j = (\sum_i (t_{ij} / \Pi_i)^{1-\sigma} \theta_i)^{1/(1-\sigma)} \quad (8)$$

Now, (7) and (8) can be solved for all Π_i's and P_i's in terms of income shares, θ_j, bilateral trade barriers, t_{ij}, and σ. If trade costs are assumed to be symmetric ($t_{ij} = t_{ji}$), solution to (7) and (8) can be demonstrated to be $\Pi_i = P_i$, with

$$P_j^{1-\sigma} = \sum_i P_i^{\sigma-1} \theta_i t_{ij}^{1-\sigma} \quad (9)$$

Hence, an implicit solution to the price indices can be obtained as a function of all bilateral trade barriers and income shares. The gravity equation becomes:

$$x_{ij} = \frac{y_i y_j}{y^w} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \quad (10)$$

As it can be appreciated, what matters in this specification is the bilateral trade cost *relative to* an overall index of trade costs; in other words, 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, is defined as a loglinear function of observed variables: bilateral distance, d_{ij}, and a dummy variable, b_{ij} that takes value 1 if *i* and *j* are located in different countries, and zero otherwise. Then:

$$t_{ij} = b_{ij} d_{ij}^{\rho} \quad (11)$$

This term is substituted in the initial equation. Adding an error term, ε_{ij}, and taking logarithms, we would have a linear standard gravity equation:

$$\ln T_{ij} = \ln y_i + \ln y_j + (1-\sigma)\rho \ln d_{ij} + (1-\sigma)\ln b_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j + \varepsilon_{ij} \quad (12)$$

2.2 Empirical specification

The specification given by equation (12) has become very standard in the gravity literature. There are two important aspects that should be taken into account when using this specification to empirically predict trade flows. One is the multilateral trade resistance terms, the other is the use of distance as a proxy for transaction costs.

In equation (12) the multilateral price indices (P_i and P_j) are not observed. Some alternatives have been proposed for estimation of these terms. A first option to approximate the price indices 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.

A 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, (distances, borders, and income shares). Assuming symmetric trade costs, using 41 goods market-equilibrium conditions[2] 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.

Another method frequently used is to include a proxy for these indexes denominated "remoteness variable":

$$Rm_i = \sum_j \frac{d_{ij}}{(y_j / y_{ROW})}$$

where the numerator would be the bilateral distance between two countries, and the denominator would be the share between each country's GDP in the rest of the world's GDP. Anderson and vanWincoop (2003) compare their previous results with a regression including his remoteness variable. They claim that this procedure is not theoretically correct, since the only trade barrier the variable captures is distance.

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 (1996) are other examples of regressions that include a remoteness variable.

The method most commonly used is the one proposed by Feenstra (2002). It consists of including importer and exporter fixed effects to account for the specific country multilateral resistance term. 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. In the appendix (table A1) we detail several studies introducing this approach, complemented by the time dimension; for instance Micco, Stein and Ordoñez (2003); Baltagi, Egger and Pfaffermayr (2003); Cheng and Wall (2005); Glick and Rose (2002); Ruiz and Vilarrubia (2007); Vicarelli and Benedictis (2004); Fidrmuc (2008); or Henderson and Millimet (2008).

Finally, Baier and Bergstrand (2009) suggest generating a linear approximation of the P_i and P_j terms by means of a first-order Taylor series expansion. This procedure is more complicated than simply including fixed effects, but it avoids the non-linear procedure employed by Anderson and vanWincoop (2003) and allows for estimation within OLS. Baier and Bergstrand's method is theoretically consistent and captures country specific and country-pair specific effects.

Concerning the proxy for supply and demand sizes used in the gravity equation, the most common feature is to use GDP for the importer and for the exporter. In some cases GDP per capita is also introduced as a proxy for capital-labour intensities (not

[2] 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.

only factor endowments of a country).

The second aspect that requires attention in this specification is the introduction of a distance variable to proxy for transaction cost. It is commonly accepted that geographical distance may be a poor approximation of all the economic barriers for international trade. In equation (12), transaction costs (t_{ij}) are proxied by bilateral distance[4], d_{ij}, and a dummy indicating the existence of a border. However, these two variables should be reinforced in order to control for other factors that may affect trade.

To control better these omitted variables, the general gravity equation proposed in equation (12) 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 trade partners 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 expected influence is positive since 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 on trade.

- Regional Trade Agreement (RTA): The effect of an RTA on trade is introduced using dummy variables. In addition, alternative specifications (Baldwin et al. 2006) includes several dummies for the cases in which none, both or only one of the two countries belong to the agreement. The effect of RTAs on trade has been widely studied due to the proliferation of these agreements in the last 20 years. Gravity equations are used to discern the existence of a regional bias in trade and to determine the trade potential associated with integration. Some articles related with this issue are Frankel, Stein and Wei (1995), Sapir (2001), Soloaga and Winters (2001), Greenaway and Milner (2002), Martínez-Zarzoso et al. (2003), Fratianni and Oh (2007) or Oh and Selmier II (2008).

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. Examples of gravity equation including technological innovation or transport infrastructure variables are provided by Freund and Weinhold (2004) or Márquez-Ramos et al. (2005).

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

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[4] In addition, there is not a unique opinion about how distance should be measured. The most common measures are the great circle formula[4] and the distance between the two principal cities. See Wei (1996), Wolf (1997), and Head and Mayer (2000) for further information.

All these factors affect international trade via transaction costs and complete the geographical distance variable in order to reflect the economic distance[5]. In our opinion, the exchange rate regime is an additional factor that has not received enough attention in the gravity literature. Both, exchange rate level and exchange rate volatility are variables affecting international trade via export price. The use of cross-section data is probably the reason for not including those variables, since the interesting effect is not the level per se, but the variation in the exchange rate. The use of panel data allows controlling for this effect in the price that a country should pay when importing.

- Exchange rate: this variable is part of the determinants of trade volume and it is expected to affect trade. The impact of real exchange-rate changes on trade is unambiguous; a real appreciation usually has a negative impact on exports through a decrease in competitiveness (demand) or a comparative increase of profitability of traded good sector against non-traded goods (supply effect).To control for this effect we have included rer_{ijt} in our specification, defined as 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* compare to *j*).

-Exchange rate volatility: The effect of exchange-rate volatility on trade flows is no so clear. McKenzie (1999) points out that 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. The impact of exchange-rate volatility actually differ according to the countries under study: Sauer and Bohara (2001) show a negative impact of exchange rate volatility on African and Latin American exports and a non-significant impact on Asian exports and on developed countries exports. Frankel and Wei (1995) evidence a significant negative impact of exchange-rate volatility on trade flows across Asian countries on a cross-section basis. Rose (2000) finds exchange-rate volatility to be a significant and systematic impediment to trade for an extensive sample of countries. Gil-Pareja et al. (2008) analyze the impact of this variable in a sample of 25 countries over the period 1950-2004 and also finds a statistically significant negative effect on trade. Tenreyro (2007) uses pseudo-maximum likelihood technique to deal with heteroscedasticity and finds opposite results. In addition, she develops an instrumental-variable (IV) version of the PML to deal with the endogeneity and the measurement error of exchange rate variability estimator. Results indicate that nominal exchange rate variability has no significant impact on trade flows.

We have included variable vol_{ijt} in our specification, defined as:

$$vol_{ijt} = \sqrt{\text{var}(\ln ner_{ij\tau} - \ln ner_{ij\tau-1})_{\{\tau=1\rightarrow 12\}}}$$

Where $ner_{ij\tau}$ is the nominal exchange rate and τ is monthly. Hence, we compute the volatility of the monthly exchange rate for a given year.

3. Estimation methods

The new workhorse in the estimation of the gravity equation is still unclear. The econometric estimation presents some challenges that remain unsolved by now. We could cite at least four estimation problems:

- *Omitted variable bias* due to the exclusion of the multilateral trade resistance

[5] Anderson (1979) theoretical foundation of the gravity equation claims that the relevant aspect in international trade flows is not *geographical* distance but *economic* distance between two countries.

terms. Anderson and van Wincoop (2003) claimed that this misspecification invalidates the estimation (see section 2.2).

- The presence of *heteroskedasticity* in trade data leads to inconsistent estimates when estimating by OLS: "*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). We will develop this issue in section 3.2.

- Some aspects affecting trade not reflected by the regressors. For instance, regulation, port efficiency, e-business, political factors, technology, etc. may differ from one country to another. This *unobserved heterogeneity* is not easily quantifiable, but should be controlled for to obtain unbiased estimates. We will treat this problem in section 3.1.

- Finally, if two countries do not trade at all, the value of their trade would be represented by a *zero value* in the dataset. This fact provokes a loss of information since the logarithm of zero is unfeasible. This problem is becoming more important due to the use of disaggregated data, in which over a 50% of values is zero. In addition, rounding or measurement errors should be distinguished of real zero values[6].

Every method presents important advantages and disadvantages and it cannot be asserted that any of them outperforms absolutely the others. For that reason, becomes a frequent practice in the literature to include several estimation methods using the same database. In our dataset the percentage of zeros only represents a 10% of the total, so we will focus on the first three problems. We will include fixed effects to avoid the problem of omitted variable bias; we will use panel estimation methods to avoid the problem of unobserved heterogeneity; and finally, we will compare these results with a Poisson Pseudo Maximum Likelihood (PPML) estimator, which deals with the problem of heteroskedasticity in trade data.

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 comparison of the absolute error loss, defined as:

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

The main advantage of this method over the bias is that over and underestimations are not canceled out. We have also calculated this function in our regressions; results can be found in the appendix. In addition, we use the Pseudo R-squared statistic to compare different models. 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.

It is also frequent to check the performance of different estimation method with Monte Carlo simulations (Silva and Tenreyro 2006, Martínez-Zarzoso et al. 2007, Martin and Pham 2008, etc.). Table A2 in the appendix detail some articles using this

[6] Recently, the problem of the zero flows has been revisited. The literature distinguishes several methods of dealing with that problem. Truncation (elimination) or censoring methods have been widely used. However, these methods have not a strong theoretical support and do not guarantee consistent estimates. Alternative solutions are Tobit estimation, Poisson Pseudo Maximum Likelihood estimation, Nonlinear Least Squares (NLS), Feasible General Least Squares (FGLS) and Helpman, Melitz and Rubinstein (2008) procedure.

methodology.

3.1. Panel techniques

Until 1990, 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 depending on the countries selected. To mitigate this problem, researchers have turned towards panel data, that is, cross-section gravity models for several consecutive years[9] (Egger 2000, Rose and van Wincoop 2001, Mátyás 1998, 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 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 arises from cross-section data is completely avoided with panel data (Baltagi, 2008, p. 6 - 11).

Fixed effect models assume that the unobserved heterogeneous component in the regression is constant over time. Dummies for importer and exporter are included in the sample, excluding one country to avoid perfect collinearity. As Mátyás (1997) points out, there may be a business cycle effect, which is common for all countries, but differs from one year to another. A dummy capturing this *time fixed effect* is then included.

However, some aspects affecting trade are not fixed along time, which may provoke a bias in the estimation. Consequently, Ruiz and Vilarrubia (2007) suggest including *exporter-yearly and importer-yearly dummies* in the regression. These variables absorb all country-specific factors, including those that vary over time.

It is probable that specific bilateral characteristics of partners influence trade –like remoteness. This can be controlled by including *country-pair fixed effect*. 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 from 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[10]. In addition, any explanatory variable that do not vary across time in each country (or pair of countries) will be perfectly collinear with the fixed effects, and should be dropped from 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.

[9] See the appendix for further information.
[10] Ruiz and Vilarrubia (2007) implement a regression with country triennial and quinquennial dummies, instead of country year dummies.

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, whereas random effects impose zero correlation. 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 (strict exogeneity).

There is a trade-off between efficiency and consistency in the random and fixed effect models: under the null hypothesis of zero correlation, random effect model is more efficient. However, if the null is rejected, only fixed effect model provides consistent estimators. The Hausman test provides a method to test the adequacy of the random effect model[11].

Fratianni and 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 the random effect model is preferred.

3.2. Poisson Pseudo Maximum Likelihood (PPML).

Another problem that arises in the estimation of the gravity equation is the “log or not to log” dilemma. The log-linearization of the error term changes the property of this error term and thus conduces to inefficient 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 estimation is not efficient.

This point has been remarked several times (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 equation (12), the expected value of the log-linearised equation would be:

$$E[\ln(X_{ijt})] = E[\alpha_1 \ln y_{it} + \alpha_2 \ln y_{jt} + \alpha_3 \ln d_{ij} + \ln(\varepsilon_{ijt})] =$$

$$E[\ln(X_{ijt})] = \alpha_1 E[\ln y_{it}] + \alpha_2 E[\ln y_{jt}] + \alpha_3 E[\ln d_{ij}] + E[\ln(\varepsilon_{ijt})]$$

Since $\ln E[\varepsilon_{ij}] \neq E[\ln(\varepsilon_{ij})]$ (Jensen’s inequality), the conditional distribution of X_{ij} is altered and the estimation through OLS will result in misleading estimates. Heteroscedasticity does not affect the parameter estimates; the coefficients should still be unbiased. However, it biases the *variance* of the estimated parameters. Consequently, the t-values for the estimated coefficients cannot be trusted.

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. Silva and Tenreyro (2006) point out that the variance of the error term is correlated with the countries' Gross Domestic Product (GDP) and with the measure of distance.

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[11] If the null is rejected, random effects model is not consistent. However, it is important to note that this result does not imply that fixed effect model is adequate.

Another source of heteroscedasticity is noted by Kalirajan (2008). He states that *economic distance* between two countries is the correct proxy for trade costs. However, the common practice is to replace it by the *geographical distance*. The cost of this simplification is the omission of some important variables related with former but not with the latter. Additionally, these non-included variables may be correlated with the included explanatory variables, and omitting them affects its variance, which will contain an upward bias. Among the aspects that are not easily quantifiable, Kalirajan cites *"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.

The *solution* proposed by Silva and Tenreyro is to estimate the model in levels, instead of taking logarithms. 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 estimation methods for a baseline gravity equation

4.1. Data

Our sample includes 47 countries from Lahrèche-Révil and Milgram (2006). It includes all the countries of the EU15 and the CEE new European members, and 6 MENA countries (Morocco, Tunisia, Egypt, Turkey, Israel and Algeria). The time sample spans from 1980 to 2002. Hence, the total possible number of observations is 49,726. Due to missing data, the available number of observations is reduced to 34,457. In addition, some observations have been manually dropped because the reported value was zero when it should be a missing value.[12]Data are collected from several sources, including CHELEM-International Trade database, CEPII's database for gravity equations World Bank data, and IFM Statistical Yearbook. [13]

4.2. Baseline model

This paper focuses on the impact of exchange-rate variables on trade flows, and on the comparison of different estimation methods. To this end, we use in a first step a baseline equation based on Anderson and van Wincoop (2003):

$$\ln(X_{ijt}) = \alpha_1 \ln y_{it} + \alpha_2 \ln y_{jt} + \alpha_3 contig_{ij} + \alpha_4 comla_{ij} + \alpha_5 smctry_{ij} + \alpha_6 \ln d_{ij} + \ln \varepsilon_{ijt}$$

The dependent variable is the logarithm of the volume of exports in constant dollars (trade data from the CHELEM-CEPII database, price indexes from the World Bank and the IMF) from country j to i. $\ln y_{it}$ and $\ln y_{it}$ are the logarithms of real PPP-converted GDPs in each country; their effect on trade is expected to be positive. $contig_{ij}$ (Contiguity), *comla* (Common language) and *smctry* (Same country) are dummy

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[12] This is the case of former USSR countries. These countries did not exist before 1993, but the value of their trade in the 1980-1992 period is registered as zero.

[13] We have opted by this CHELEM database because data reported is previously depurated using a 7-step procedure: bilateral trade data is harmonized using reports of each one of the countries involved in the transaction.

variables that take value 1 when two countries share a border, a language, or were the same country in the past, correspondingly. In both cases, the coefficient is expected to be positive. d_{ij} is a variable representing the bilateral distance between i and j and is obtained from CEPII database. It is expected to have a negative influence on trade.

4.3 Results

The empirical model is estimated through different estimation methods: OLS, panel regression with fixed and random effects and simple and panel Poisson methodology.

First of all, we have conducted some specification tests. On the one hand, if unobserved heterogeneity is present, OLS estimation yields biased and inconsistent estimates. Hence, we should, first of all, test the existence of fixed effects. We have tested this using both, Likelihood Ratio (LR) and Lagrange Multiplier (LM) tests on time and individual effects. In both cases, we reject the null hypothesis of no fixed effects. In addition, the standard F-test for the joint significance of individual and time dummies confirms our results. Hence, OLS results are biased and inconsistent, and should not be used as estimation method in this case.

In order to choose between fixed and random effect models, we have performed a Hausman test. Under the null hypothesis, the random effect model is assumed to be consistent and efficient. In all cases we reject the null and conclude that the random effect model is not appropriate.

Finally, to test for the presence of heteroscedasticity we have implemented the White's general test in OLS regressions and the modified Wald statistic for groupwise heteroscedasticity in fixed effect models. In all our results, the null hypothesis of homoscedasticity is rejected. A simple method to correct for heteroscedasticity is to use robust standard errors: OLS and panel regressions assume that errors are both independent and identically distributed; robust standard errors relax either or both of those assumptions.

Concerning the fixed effect estimation, we should mention that we are estimating a three-way error component model. Within transformation in Stata only deals with one of the three effects that we want to estimate. For that reason, we use the "fixed effect least square dummy variable" (FELSDV) approach (Andrews et al. 2006); we apply the within transformation to eliminate the exporter effects and introduce dummy variables to include the importer and time effects.

As expected, the exporter and importer real GDP both increase exports regardless of 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 proximity (either in history or in space) tends to increase exports. The only exception is 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 "Common language" 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. (2008). Unlike these authors, we do not appreciate important asymmetries in the coefficients of importer's and exporter's GDP using Poisson.

5. Comparing estimation methods for a gravity equation taking into account EMU

The debate on the effect of a currency union on trade is not concluded at all. On the one hand, some authors point out that a currency union promotes trade since it eliminates transaction costs and exchange rate volatility. On the other hand, other authors claim that the gains derived from reducing volatility are not expected to be so high, since there are many financial instruments to hedge against exchange rate risks.

However, it should be noted that the elimination of volatility is not the unique effect of a currency union. The increase in the degree of transparency or the perception of irrevocability are other factors promoting trade.

Adding some variables to the previous model we intend to distinguish the specific currency union effect on trade from other political effects (free trade area, exchange rate volatility) derived from the convergence process that has lead the creation of EMU.

5.1. Alternative specifications

Taking the previous equation as starting point, we have estimated three additional equations in order to control for the effects of exchange rate, exchange rate volatility and trade and currency agreements. By including dummies for trade and monetary agreements, we will try to estimate how a fixed peg could affect third countries exports to the EMU and to other zones.

In the second case, we measure the sensitiveness of exports to exchange-rate regimes introducing the level and the volatility of the exchange rate:

$$\ln(X_{ijt}) = \alpha_1 \ln y_{it} + \alpha_2 \ln y_{jt} + \alpha_3 contig_{ij} + \alpha_4 comla_{ij} + \alpha_5 smctry_{ij} + \alpha_6 \ln d_{ij} + \alpha_7 \ln rer_{ijt} + \alpha_8 vol_{ijt} + \varepsilon_{ijt}$$

where:

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 compare to j).

vol_{ijt} is a measure of volatility, defined as the standard deviation of the rate of change of exchange-rate series:

$$vol_{ijt} = \sqrt{\mathrm{var}(\ln ner_{ij\tau} - \ln ner_{ij\tau-1})_{\{\tau=1\to 12\}}}$$

The third specification aims at including the effects of having a trade agreement or belonging to a currency union. With that purpose, we include four additional variables.

$$\ln(X_{ijt}) = \alpha_1 \ln y_{it} + \alpha_2 \ln y_{jt} + \alpha_3 contig_{ij} + \alpha_4 comla_{ij} + \alpha_5 smctry_{ij} + \alpha_6 \ln d_{ij} + \alpha_7 \ln rer_{ijt} + \alpha_8 vol_{ijt} + \alpha_9 RTAone + \alpha_{10} RTAboth + \alpha_{11} EMUone + \alpha_{12} EMUboth + \varepsilon_{ijt}$$

where:

EMUone and *EMUboth* are two variables that take value one when one or both countries respectively belong to the EMU, and zero otherwise. These variables allow assessing the effect of the EMU on non EMU countries exports.

RTAone and *RTAboth* take value one when one or both countries have a regional trade agreement (RTA), and zero otherwise. With the inclusion of these variables, we intend to capture possible creation or diversion effects. Hence, a positive sign on these variables would imply that belonging to a RTA or to the EMU generate an increase in that country's exports, whereas a negative sign would mean that a diversion effect is taking place.

Finally, in a fourth equation, we introduce two additional dummies (EMUimp and EMUexp) to distinguish among the cases in which only the exporter or only the importer belongs to the EMU:

$$\ln(X_{ijt}) = \alpha_1 \ln y_{it} + \alpha_2 \ln y_{jt} + \alpha_3 contig_{ij} + \alpha_4 comla_{ij} + \alpha_5 smctry_{ij} + \alpha_6 \ln d_{ij} + \alpha_7 \ln rer_{ijt}$$
$$+ \alpha_8 vol_{ijt} + \alpha_9 RTAone + \alpha_{10} RTAboth + \alpha_{11} EMUimp + \alpha_{12} EMU\exp + \alpha_{12} EMUboth + \varepsilon_{ijt}$$

where EMUimp takes value 1 if the importer involved in the trade flow belongs to the EMU and zero otherwise. Analogously, EMUexp takes value 1 when the exporter belongs to EMU and zero otherwise. We are especially interested in the sign of the variable EMUimp. A negative sign would imply a diversion effect of EMU, since EMU countries are substituting their imports from the rest of the world by imports of EMU countries. By contrast, a positive sign can be interpreted as an increase of the exports of third countries to EMU (creation effects).

In the fixed effect model, we decompose the error term such that $\varepsilon_{ij} = \beta_i + \beta_j + \beta_t + u_{ijt}$ where β_i, β_j and β_t are vectors of fixed effects for the exporting countries, importing countries and time (yearly frequency). In addition, we estimate an additional equation in which we replace country individual fixed effect by country-pair fixed effects.

5. 2. 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. We first study the impact of real exchange rate and volatility of the exchange rate on trade flows.

When studying the impact of real exchange rate and volatility on exports (Table B2), the real exchange rate has the expected positive sign except in the Poisson regression with random effects. 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 effect 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 0.2 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% according 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 regressions 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 more imports from third countries than from EMU. 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.

If we look at the results of intra EMU trade, creation effects are unambiguously shown, both under panel and poisson estimation: coefficients of dummies for one or both countries belonging to an RTA are always positive.

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. Robustness checks

We have re-estimated the second equation introducing some changes in the regressions in order to check the robustness of the results:

a) One of the advantages of the estimation using Poisson Pseudo Maximum Likelihood is the possibility of using observations that take zero value. To check if the exclusion of the zero flows has a significative effect on the estimation we have re-estimated Poisson regressions dropping manually zero trade flows. Results do not change substantially.

b) Frequently, countries that have belonged to the same country in the past are very close each other. Hence, we may expect some kind of relationship between contiguity and same country. Using both variables at the same time may induce to multicollinearity in the regressions. We have performed different checks dropping alternatively "Contiguity" and "Same country". We have not found a significant change in the results in any of the two cases.

c) We have data from 1980 to 2002. During these years the geography of some zones of the world was restructured; some countries were divided whereas other disappeared. For that reason, we think that it could be interesting to reduce the sample and repeat the estimation for a shorter period (1993-2002), in which geopolitical conditions have been more or less stable. The coefficient for "one member has RTA" becomes negative in the Poisson estimation. Additionally, some of the coefficients in the panel regressions (Both partners have FTA, One partner is in EMU, Volatility of the ER) become insignificant.

d) The inclusion of volatility of the nominal ER or the level of the ER itself is not standard in the gravity literature. Consequently, we have run two additional regressions, one of them including only volatility and another dropping both, volatility and level of ER. In both cases, changes are not very important. The significance, sign and magnitude of the coefficients is not altered in a substantial way.

e) In order to assess the Euro effect on exports between EMU countries (intra-EMU trade) we have repeated the estimations for a subsample of countries including only EMU countries.[19]

f) To assess Euro effects on exports between non EMU countries we have included a new set of dummies: *RTAone_noeuro* takes value one when one of the partners belongs to a RTA different from EMU and zero otherwise; *RTAone_euro* takes value one when one of the partners belong to a RTA and to EMU; *RTAboth_euro* takes value one if both countries belong to EMU and *RTAboth_noeuro* takes value one when both countries belong to a RTA different from EMU.

g) Finally, we think that volatility of the exchange rate may have a different effect on exports before and after the euro. Hence, we have introduced a new set of dummies.

VOLNE 80-98 reports the value of volatility for the period 1980-1998 and zero otherwise; and VOLNE 99-02 reports the value of volatility for the period 1999-2002. To test the same effect between non EMU countries and exports from EMU to third countries we have split those variables into three different dummies (one, both or none of the countries belong to EMU).

All in all, we don't find any important modification in our previous results. Overall, the most important finding concerns methodological issues. The signs of coefficients of continuous variables do not change so much from one method to another while panel with fixed effects drive opposite conclusions from Poisson for dummies. Empirical works using dummies should be very cautious about the estimation method they used. For our empirical model, Poisson estimates leads to results more in line with theoretical predictions. Thus, when we reduce our sample to the intra-EMU trade, which is a more homogeneous sample, both estimation methods leads to expected results.

7. Concluding remarks

The choice of an exchange rate regime, the possibility to peg or not 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

[19] See De Nardis and Vicarelli (2003)

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 and 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 to study.

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Appendix

A. Literature review

Table A1. Articles using fixed effects, random effects or both in the estimation of the gravity equation

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 - Symmetric country-pair effects (i.e., $\alpha ij = \alpha ji$).	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 effects - Exporter time 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
De Benedictis and Vicarelli (2005)	- 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 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 and 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
Oh and Selmier II (2008)	- Country-pair fixed effects - 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 (2007)	- 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 to deal with the problem of zero-flows and heteroscedasticity.

Article	**Countries and years**	**Estimation methods**	**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 Dummies 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 (2009)	1992-2002; 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)	1970-1997; 158 countries	HMR (Probit and OLS), NLS, semiparametric, non-parametric	Aggregated data	Exports	No
Martin and Pham (2008)	Dataset from Silva and Tenreyro (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)	1986 (cross-section); 158 countries;	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

List of countries included in the sample

Algeria
Australia
Austria
Belgium and Luxembourg
Bulgaria
Canada
Chine
Croatia
Czech Republic
Denmark
Egypt
Estonia
Finland
France
Germany
Greece
Hong Kong
Hungary
India
Indonesia
Ireland
Israel
Italy
Japan
Latvia
Lithuania
Malaysia
Mexico
Morocco
Netherlands
New Zealand
Philippines
Poland
Portugal
Romania
Singapore
Slovakia
Slovenia
South Korea
Spain
Sweden
Taiwan
Thailand
Tunisia
Turkey
United Kingdom
USA

Table B1. Baseline model. Logarithm of exports

	Panel fixed effects	**Panel fixed effects**	**Panel random effects**	**Poisson fixed effects**	**Poisson fixed effects**	**Poisson random effects**
Log of exporter real GDP	0.768*** [0.036]	0.826*** [0.023]	0.568*** [0.049]	0.722*** [0.073]	0.672*** [0.001]	0.739*** [0.001]
Log of importer real GDP	0.576*** [0.039]	0.831*** [0.023]	0.240*** [0.007]	0.576*** [0.043]	0.689*** [0.001]	0.631*** [0.000]
Contiguity	-0.280*** [0.043]		0.514*** [0.046]	0.447*** [0.028]		0.589*** [0.000]
Common Language	0.682*** [0.024]		1.217*** [0.030]	0.199*** [0.024]		0.369*** [0.000]
Same Country	0.706*** [0.067]	-0.390*** [0.119]	0.105* [0.055]	0.144*** [0.043]	-0.332*** [0.003]	-0.049*** [0.001]
Log of Distance	-1.249*** [0.008]		-0.807*** [0.010]	-0.717*** [0.007]		-0.621*** [0.000]
Constant	-20.586*** [1.372]	-37.515*** [1.180]	-9.326*** [1.281]	-23.234*** [1.915]		-16.576*** [0.448]
Observations	38,643	38,643	38,643	39,202	39,202	39,202
R-squared	0.732	0.180	0.17			
Pseudo R-squared				0.89	0.04	0.69
Exporter fixed effects	Yes (within)	No	No	Yes (within)	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is logarithm of exports for panel regressions and exports in levels for poisson regressions.						

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

	Panel fixed effects	**Panel fixed effects**	**Panel random effects**	**Poisson fixed effects**	**Poisson fixed effects**	**Poisson random effects**
Log of exporter real GDP	0.892*** [0.047]	1.040*** [0.075]	0.975*** [0.049]	0.928*** [0.001]	0.824*** [0.001]	0.980*** [0.001]
Log of importer real GDP	0.792*** [0.049]	0.951*** [0.076]	0.974*** [0.006]	0.670*** [0.001]	0.835*** [0.001]	0.817*** [0.000]
Contiguity	-0.358*** [0.043]		-0.138*** [0.042]	0.379*** [0.001]		0.428*** [0.000]
Common Language	0.727*** [0.025]		1.106*** [0.025]	0.247*** [0.000]		0.374*** [0.000]
Same Country	0.957*** [0.068]	-0.380* [0.200]	0.657*** [0.056]	0.259*** [0.001]	-0.329*** [0.003]	0.322*** [0.001]
Log of Distance	-1.218*** [0.008]		-1.062*** [0.009]	-0.725*** [0.000]		-0.669*** [0.000]
Log of RERij	0.336*** [0.031]	0.148*** [0.048]	0.280*** [0.030]	0.135*** [0.001]	-0.024*** [0.001]	-0.201*** [0.001]
Volatility	-0.731*** [0.159]	-0.850*** [0.124]	-2.486*** [0.164]	-3.589*** [0.009]	-1.170*** [0.008]	-4.774*** [0.008]
Constant	-29.861*** [1.684]	-46.702*** [3.875]	-36.782*** [1.275]			-34.878*** [0.108]
Observations	34,893	34,893	34,893	35,324	35,324	35,324
R-squared	0.735	0.194	0.62			
Pseudo R-squared				0.23	0.14	0.21
Exporter fixed effects	Yes (within)	No	No	Yes (within)	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No

Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is logarithm of exports for panel regressions and exports in levels for poisson regressions.

Table B3. Effect of RTAs on exports

	Panel fixed effects	**Panel fixed effects**	**Panel random effects**	**Poisson fixed effects**	**Poisson fixed effects**	**Poisson random effects**
Log of exporter real GDP	0.872*** [0.047]	1.059*** [0.077]	0.981*** [0.049]	0.970*** [0.001]	0.845*** [0.001]	1.068*** [0.001]
Log of importer real GDP	0.767*** [0.049]	0.968*** [0.078]	0.957*** [0.006]	0.699*** [0.001]	0.858*** [0.001]	0.821*** [0.000]
Contiguity	-0.340*** [0.043]		-0.088** [0.041]	0.350*** [0.001]		0.380*** [0.000]
Common Language	0.731*** [0.024]		1.156*** [0.025]	0.285*** [0.000]		0.429*** [0.000]
Same Country	0.958*** [0.067]	-0.378* [0.198]	0.797*** [0.057]	0.324*** [0.001]	-0.329*** [0.003]	0.444*** [0.001]
Log of Distance	-1.211*** [0.009]		-0.958*** [0.010]	-0.621*** [0.000]		-0.549*** [0.000]
Log of RERij	0.338*** [0.031]	0.145*** [0.048]	0.250*** [0.029]	0.127*** [0.001]	-0.023*** [0.001]	-0.227*** [0.001]
Volatility	-0.702*** [0.161]	-0.731*** [0.121]	-2.169*** [0.168]	-3.039*** [0.009]	-1.208*** [0.008]	-4.069*** [0.008]
One partner has FTA	0.218*** [0.025]	0.102** [0.051]	0.507*** [0.026]	-0.097*** [0.001]	-0.051*** [0.001]	-0.034*** [0.000]
Both partners have FTA	0.101*** [0.019]	0.286*** [0.044]	0.432*** [0.020]	0.437*** [0.000]	0.143*** [0.000]	0.521*** [0.000]
One partner in EMU	0.190*** [0.024]	0.004 [0.036]	0.486*** [0.028]	-0.058*** [0.001]	0.010*** [0.001]	-0.000 [0.001]
Both partners in EMU	-0.372*** [0.047]	-0.049 [0.047]	-0.048 [0.042]	0.031*** [0.001]	-0.075*** [0.001]	0.079*** [0.001]
Constant	-28.861*** [1.712]	-47.694*** [3.984]	-37.669*** [1.278]			-38.268*** [0.111]
Observations	34,893	34,893	34,893	35,324	35,324	35,324
R-squared	0.736	0.199	0.64			
Pseudo R-squared				0.23	0.15	0.21
Exporter fixed effects	Yes (within)	No	No	Yes (within)	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is logarithm of exports for panel regressions and exports in levels for poisson regressions.						

Table B4. RTA and EMU diversion effects

	Panel fixed effects	Panel fixed effects	Panel random effects	Poisson fixed effects	Poisson fixed effects	Poisson random effects
Log of exporter real GDP	0.875*** [0.048]	1.058*** [0.077]	0.952*** [0.049]	0.970*** [0.001]	0.846*** [0.001]	1.065*** [0.001]
Log of importer real GDP	0.766*** [0.049]	0.968*** [0.078]	0.954*** [0.006]	0.691*** [0.001]	0.858*** [0.001]	0.821*** [0.000]
Contiguity	-0.340*** [0.043]		-0.086** [0.041]	0.349*** [0.001]		0.379*** [0.000]
Common Language	0.732*** [0.024]		1.162*** [0.025]	0.283*** [0.000]		0.428*** [0.000]
Same Country	0.953*** [0.067]	-0.377* [0.199]	0.791*** [0.057]	0.326*** [0.001]	-0.330*** [0.003]	0.444*** [0.001]
Log of Distance	-1.211*** [0.009]		-0.955*** [0.010]	-0.621*** [0.000]		-0.549*** [0.000]
Log of RERij	0.338*** [0.031]	0.148*** [0.048]	0.254*** [0.029]	0.122*** [0.001]	-0.019*** [0.001]	-0.226*** [0.001]
Volatility	-0.703*** [0.161]	-0.729*** [0.121]	-2.135*** [0.168]	-3.015*** [0.009]	-1.209*** [0.008]	-4.059*** [0.008]
One partner has RTA	0.218*** [0.025]	0.102** [0.051]	0.493*** [0.026]	-0.099*** [0.001]	-0.051*** [0.001]	-0.035*** [0.000]
Both partners have RTA	0.101*** [0.019]	0.289*** [0.044]	0.417*** [0.020]	0.436*** [0.000]	0.145*** [0.000]	0.521*** [0.000]
EMUimp	0.174*** [0.031]	-0.081* [0.049]	0.680*** [0.032]	-0.092*** [0.001]	-0.052*** [0.001]	-0.015*** [0.001]
EMUexp	0.192*** [0.028]	0.067 [0.041]	0.233*** [0.036]	-0.063*** [0.001]	0.067*** [0.001]	-0.015*** [0.001]
Both partners in EMU	-0.182*** [0.050]	-0.050 [0.047]	0.401*** [0.045]	-0.037*** [0.001]	-0.066*** [0.001]	0.072*** [0.001]
Constant	-28.889*** [1.713]	- 47.687*** [3.987]	- 36.896*** [1.294]			-38.179*** [0.111]
Observations	34,893	34,893	34,893	35,324	35,324	35,324
R-squared	0.736	0.200	0.63			
Pseudo R-squared				0.23	0.15	0.21
Exporter fixed effects	Yes (within)	No	No	Yes (within)	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors in brackets. EMUimp takes value one when the importer belongs to EMU and EMUexp when the exporter belongs to EMU. The dependent variable is logarithm of exports for panel regressions and exports in levels for poisson regressions.

Table B5. Euro effect on Intra-EMU trade

	Panel fixed effects	**Panel fixed effects**	**Panel random effects**	**Poisson fixed effects**	**Poisson fixed effects**	**Poisson random effects**
Log of exporter real GDP	1.373*** [0.110]	0.969*** [0.130]	0.862*** [0.012]	1.106*** [0.005]	1.122*** [0.004]	1.078*** [0.005]
Log of importer real GDP	0.569*** [0.092]	0.968*** [0.121]	0.862*** [0.012]	1.109*** [0.007]	1.100*** [0.004]	0.809*** [0.000]
Contiguity	0.455*** [0.030]		-0.052 [0.040]	0.395*** [0.001]		0.324*** [0.001]
Common Language	0.227*** [0.044]		0.382*** [0.046]	0.688*** [0.001]		0.638*** [0.001]
Same Country	0.346*** [0.052]		0.580*** [0.054]	0.533*** [0.001]		0.653*** [0.001]
Log of Distance	-0.372*** [0.030]		-0.924*** [0.031]	-0.229*** [0.001]		-0.296*** [0.001]
Log of RERij	0.554*** [0.090]	-0.04 [0.207]	-0.04 [0.116]	0.146*** [0.004]	-0.049*** [0.004]	0.006 [0.004]
Volatility	-2.873** [1.187]	-3.477*** [1.019]	-5.602*** [1.970]	-3.863*** [0.048]	-3.751*** [0.048]	-4.892*** [0.047]
One partner has FTA	0.578*** [0.070]	0.384*** [0.066]	0.568*** [0.151]	1.036*** [0.019]	0.574*** [0.020]	1.122*** [0.019]
Both partners have FTA	0.223*** [0.023]	0.222*** [0.055]	0.132*** [0.033]	0.322*** [0.001]	0.335*** [0.001]	0.288*** [0.001]
Both partners in EMU	0.082 [0.072]	0.082 [0.097]	0.656*** [0.143]	0.059*** [0.005]	0.038*** [0.005]	0.204*** [0.005]
Constant	-41.962*** [3.850]	-43.913*** [6.408]	-31.941*** [0.606]			-40.930*** [0.195]
Observations	2,530	2,530	2,530	2,530	2,530	2,530
R-squared	0.926	0.511	0.89			
Pseudo R-squared				0.6	0.49	0.61
Exporter fixed effects	Yes (within)	No	No	Yes (within)	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No

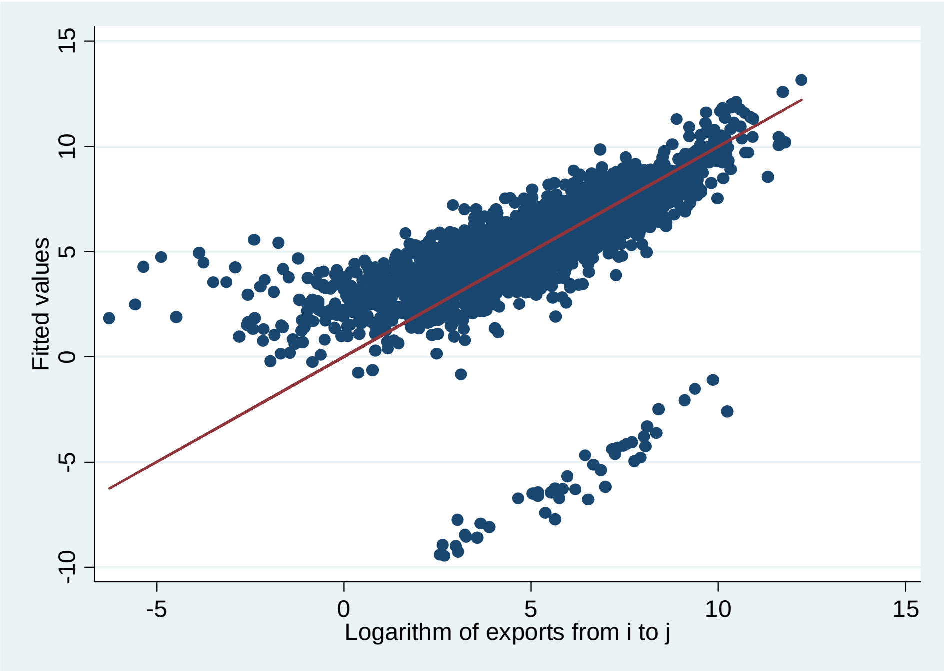
Notes: Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is logarithm of exports for panel regressions and exports in levels for poisson regressions. The sample is reduced to EMU countries (importers and exporters).

Table B6. Absolute error loss

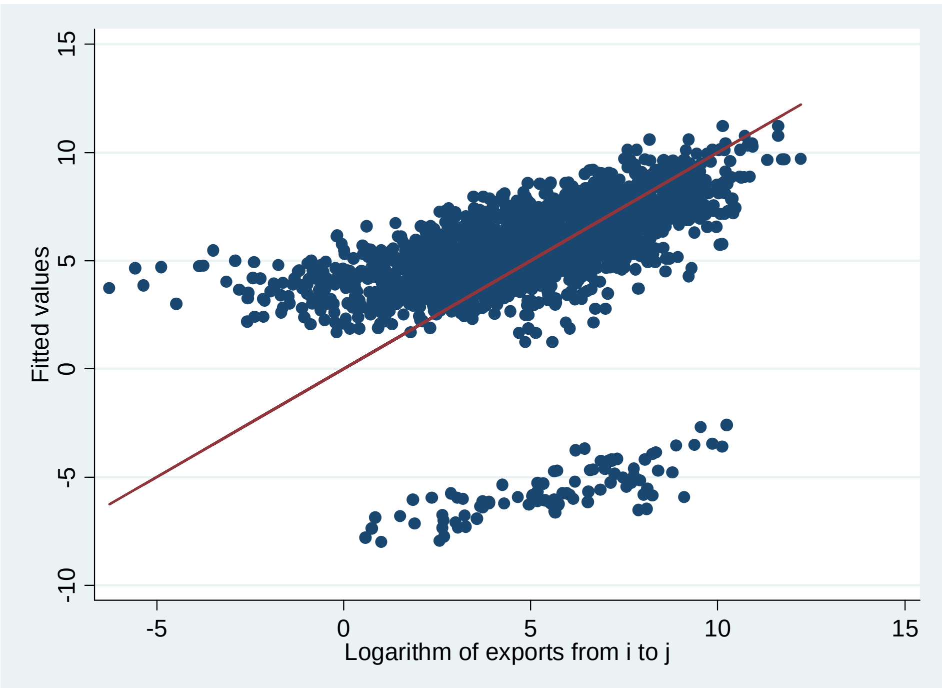
	Baseline specification	2nd specification	3rd specification	4th specification	Intra-EMU trade
Panel fixed effects	1.445987	1.129925	1.128825	1.127984	0.7121354
Panel fixed effects (country pairs)	2.038574	1.51685	1.47395	1.473684	0.6887974
Panel random effects	1.79247	1.212452	1.166107	1.173173	0.471266
Poisson fixed effects	1.036278	2.397335	2.344079	2.344146	3.388448
Poisson fixed effects (country pairs)	2.418417	2.329464	2.294904	2.294923	3.364352
Poisson random effects	8.609772	3.552146	3.54696	3.546939	5.381084

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

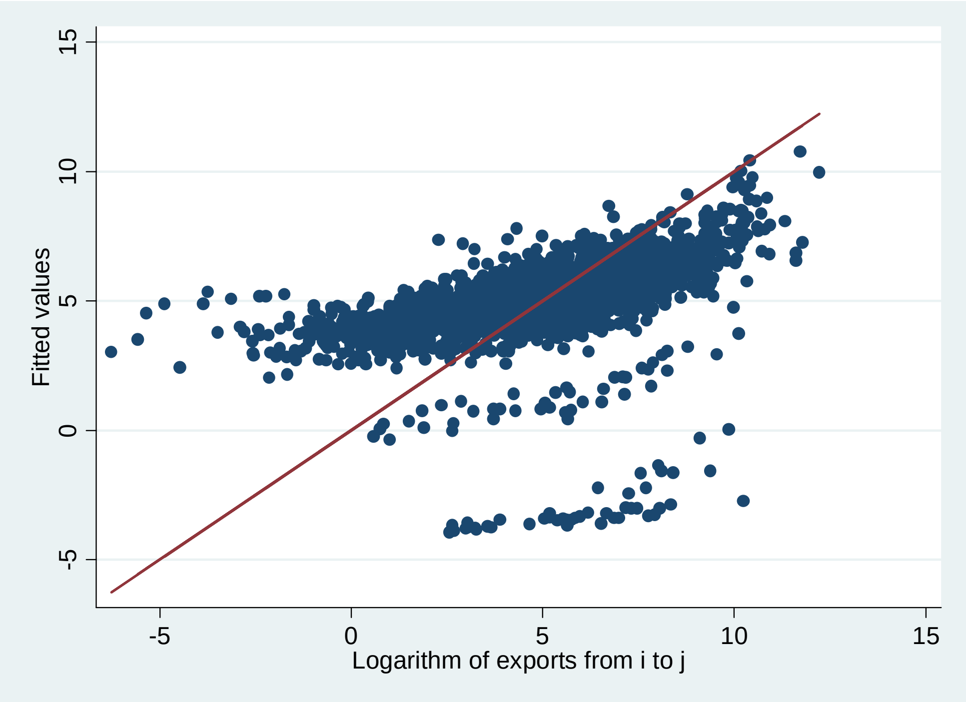
C1. Cross- validation for panel regression. Exporter, importer and time fixed effects



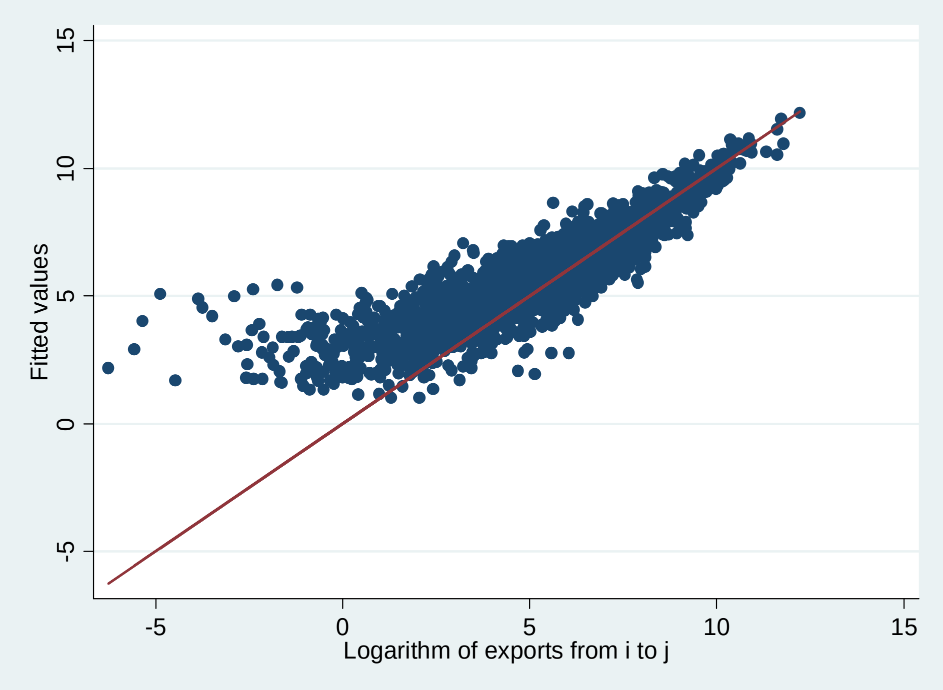
C2. Cross- validation for Panel regression. Country pair fixed and time effects



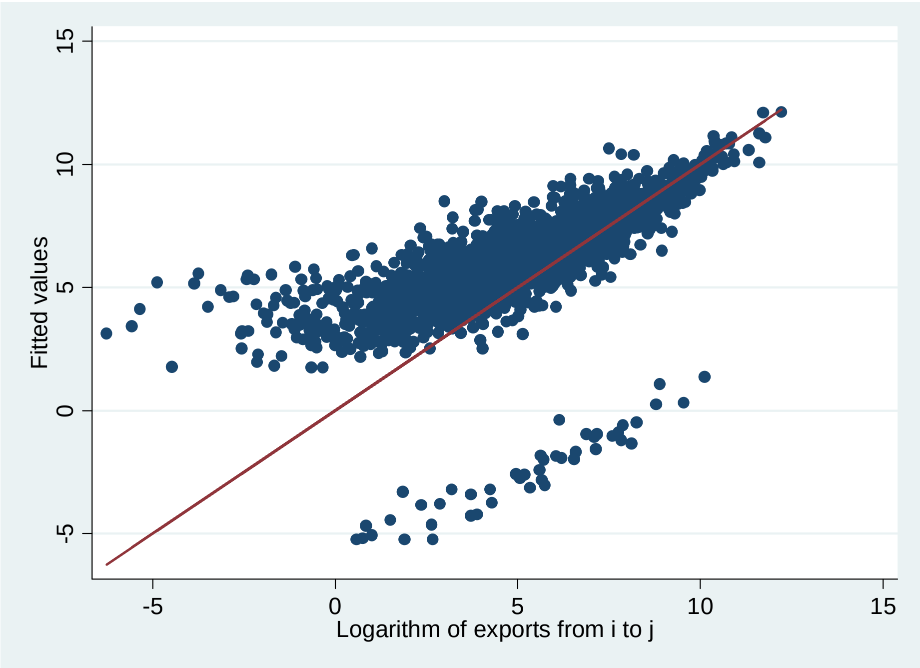
C3. Cross- validation for Panel regression. Random effects



C4. Cross- validation for Poisson regression. Exporter, importer and time fixed effects



C5. Cross-validation for Poisson regression. Country pair and time fixed effects



C6. Cross-validation for Poisson regression with random effects