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Harry Kelejian
George S. Tavlas
Pavlos Petroulas

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BANK OF GREECE
Economic Research Department – Special Studies Division
21, E. Venizelos Avenue
GR-102 50 Athens
Tel: +30210-320 3610
Fax: +30210-320 2432

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IN THE NEIGHBOURHOOD: THE TRADE EFFECTS OF THE EURO IN A SPATIAL FRAMEWORK

Harry Kelejian
Department of Economics, University of Maryland.

George S. Tavlas
Bank of Greece

Pavlos Petroulas
Bank of Greece

ABSTRACT

Trade is spatial in nature. However, when specifying trade regressions, spatial issues are typically not accounted for in a satisfactory way. We specify a trade model which relates to the effects that the introduction of the euro had on exports for the euro countries. Our model contains country pair fixed effects and error terms which are spatially and time autocorrelated, as well as heteroskedastic. Our spatial weighting matrix has unique characteristics. Our model also allows for endogenous regressors, and so we estimate it by an instrumental variable procedure. We find that the results of estimation are substantially affected when one accounts for statistical complications. Specifically, euro effects on exports are significantly reduced and are only "borderline" significant. Also, dummy variables measuring the effects of EU-membership on exports become insignificant. The results relating to other variables do not seem to be substantially affected. All of this suggests that, perhaps, the effects of currency unions on trade as described in the previous literature has been severely overstated.

Keywords: Trade, EMU, Spatial Econometrics, Panel Data
JEL classification: F15; F33; C31; C33

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Correspondence:
Pavlos Petroulas,
Economic Research Department,
Bank of Greece, 21 E. Venizelos Ave.,
102 50 Athens, Greece,
Tel. +30210-320 2643
Email: ppetroulas@bankofgreece.gr

1 Introduction

During the past decade, a rapidly expanding empirical literature has emerged assessing the effects of a common currency on trade. This literature has, by-and-large, been a reaction to Rose's (2000) surprising finding (based on a panel data set that included almost all countries in the world) that a currency union, on average, triples the size of trade flows among the members of the union. This finding has been viewed as an important benefit derived from joining a common-currency area for at least two reasons. First, increased trade integration typically leads to higher business-cycle correlation, so that a single monetary policy would be more appropriate than otherwise (Frankel and Rose, 1998).[1] Second, increased trade integration is said to set in motion dynamic economies of scale, including the accumulation of knowledge, raising potential output (Frankel and Rose, 2002; De Grauwe, 2007).[2]

Rose's findings (2000) were based on the gravity model, which is usually estimated by ordinary least squares (OLS). The model is typically specified so as to include the GDPs of two economies (i.e., trade partners), the distance between them, and the land areas of the economies, as explanatory variables. Dummy variables are included to capture the possible effects of common features of the economies considered, including membership in a free-trade area or currency union (i.e., the "Rose effect"), a common language, border effects, and so on.

The literature generated by Rose's study (2000) aimed mainly to test the robustness of Rose's results to changes in the estimation methodology and the data sample.[3] Focus has been placed on re-specification of the gravity model (e.g., inclusion of non-linear effects of GDP on trade, country-pair effects) and changes in the global data set used by Rose.[4] This research has resulted in a downward adjustment of the estimated impact of a common currency on trade, to a range of 20-40 per cent (Rose, 2008). This work, however, is subject to several major criticisms, which include the following. First, the global samples used include countries that have very different structural characteristics so that the results may not be relevant for a particular group of countries with similar characteristics - - e.g., the particular kind of group that is most likely to form a currency union (e.g., the members of the euro area). Second, the global data sets used include cases of break-ups of monetary

[1] As Frankel and Rose (1998) argued, the optimum-currency-area conditions needed for the adoption of a common currency are partly endogenous.

[2] Effectively, increased trade integration is said to lead to an upward shift in an economy's aggregate production function (De Grauwe, 2007, pp. 72-77).

[3] Among the early authors to critisize Rose's results on econometric grounds were Nitsch (2002) and Persson (2001).

[4] See, for example, Persson (2001), Rose and van Wincoop (2001), Nitsch (2002) and Glick and Rose (2002).

unions. Such break-ups typically involve large disruptions to trade that tend to drive the results. However, the break-up of monetary unions often reflects political factors so that results that include such episodes may not give an accurate depiction of the relationship between monetary unions and trade. Thus, the results probably do not adequately reflect the pure trade-creation effects of entry into a currency union.

With the formulation of the euro area in 1999, and the associated availability of data with regard to that monetary union in recent years, researchers have increasingly been able to address the above problems, since the euro area countries are relatively-homogenous.[5] The upshot of the empirical studies for the euro area is that the estimated trade effects of a common currency is considerably smaller than the initial estimates derived by Rose, but is nevertheless sizeable - - generally in the range of 7 to 25 per cent.[6]

As mentioned, gravity models are typically estimated by ordinary least squares. Also, in the literature, bilateral trade between two countries, say (i) and (j), is usually assumed to depend only on the attributes of the two countries considered. These standard features of the gravity model and its estimation seem to be at odds with a multi-country framework for trade for several reasons.

First, consider the lack of spatial analysis in the gravity framework. Under the bilateral-trade set-up, impacts from the rest of the world, i.e., third country effects, are excluded from consideration. Second, the standard gravity approach omits consideration of the persistence of trade that seems to characterize trade among countries.[7] Third, the standard approach typically omits consideration of the possible endogeneity of certain explanatory variables (other than the currency union itself). Fourth, these gravity model estimations, even if based only on the data of countries comprising the euro area, fail to take account of differences in structural characteristics that may lead the countries under consideration to react asymmetrically to identical shocks.

In this paper, we address the above four issues. Specifically, we specify and estimate a generalization of the typical gravity model which includes country pair

[5] As we point out below, however, the countries that form the euro area nevertheless may differ in their reactions to identical shocks.

[6] Relevant studies include, among others, Micco et al. (2003), Barr et al. (2003), De Nardis et al. (2008), Baldwin et al.(2005), Baldwin and Di Nino (2006), Flam and Nordström (2006a, 2006b), Bun and Klaasen (2007) and Berger and Nitsch (2008). Baldwin (2006) reviews the literature on the effects of a currency union on trade, with a particular reference to the euro.

[7] The studies by De Nardis et al. (2008), Bun and Klaasen (2007) and Berger and Nitsch (2008) are exceptions.

fixed effects, third country effects, endogenous regressors, and error terms that are both spatially and time autocorrelated. These error terms are specified in such a way that the extent of spatial and time autocorrelation are country specific, as are their variances.

The incorporation of the above factors into the gravity set-up substantially alters the estimated effects of the introduction of the euro on exports. Specifically, the estimated euro effects on exports are significantly less than those reported in the literature, and are only borderline significant. We also find that third country effects are significant in determining trade. The fact that our other explanatory variables generally retain their significance provides a strong confirmation of our suggested estimator. So-to-speak, the bottom line is that our results suggest that the effects of currency unions on trade in the earlier literature have been overstated.

The remainder of the paper is structured as follows. Section 2 provides some intuition as to the spatial nature of trade and its persistence over time. In Section 3 we present and discuss our model. Section 4 outlines the estimation procedure and presents the results. Section 5 concludes. Technical details concerning estimation are relegated to the appendix.

2 Trade: gravity models, spatial issues and persistence

The "new economic geography" theories provide the analytic basis for a spatial analysis of economic data in such areas as regional convergence, regional concentration of economic activity and, of course, trade.

The results given by Anderson and van Wincoop (2003) imply that the relevant export costs for exports from country (i) to country (j), is the cost of exporting from (i) to country (j) relative to the cost of exporting from (i) to all other potential importing competitors of $(j)-$ e.g., there are third country effects. In typical gravity models, however, these third country effects are not modeled but, instead, are assumed to be captured by country(-pair) fixed effects. There are at least two problems with this "typical" approach. First, a certain element of comprehension is lost since third country effects can not be estimated if third country effects are not modeled; that is, country pair fixed effects undoubtably reflect factors in addition to third country effects. Second, country pair fixed effects are constant over time while third country effects need not be.[8]

[8] Recent theoretical studies, including those by Rossi-Hansberg (2005), Grossman et al. (2006) and Markusen

Even a casual observation of the specialization patterns across space and employment concentration shows that the distribution of economic activity in space is neither uniform nor perfectly concentrated. Thus, in an analysis of the trade-creation effects of a single currency, it is important to specify a model and an estimation procedure that account for distribution of data in space. The importance of spatial effects has been highlighted in the closely linked literature of foreign direct investment and the activity of multinational enterprises. Recent studies, including those of Baltagi et al. (2007, 2008), Blonigen et al. (2007) and Hall and Petroulas (2008), confirm the importance of spatial effects for the location of foreign direct investment. Since a large part of world trade is intra-firm, spatial effects are also apt to be important for trade.[9] In our model we allow for the spatial aspects of trade between countries (i) and (j) through two channels. First, our regression model contains two distance-weighted, spatially-lagged GDP variables. One of these variables relates to competing potential export suppliers; the other relates to competing potential import demanders - our "third" country variables. The distances involved in the specification of these variables are country-pair specific. Second, we allow the regression errors to be spatially correlated and our specification is reasonably general.

Bilateral trade tends to be persistent over time. In this connection, a key finding of the literature dealing with productivity, market entry and survival of exporting firms, is that the main explanatory variable that determines the survival of an exporter (that is, whether the firm will also be an exporter in the following period) is persistence, proxied by lagged export status.[10] According to Melitz (2003), participation decisions, as to whether to become an exporter, are determined by a combination of sunk-costs that occur in becoming an exporter, and firm productivity.[11] The persistence coefficient is usually interpreted as evidence of sunk-costs and its magnitude varies across countries. Another factor considered in the literature on market entry concerns the trade exposure of an industry. An industry with a high 'trade exposure' increases the probability that a given firm in the industry will enter the export market. One explanation for this result could be (implicit) lower sunk costs. In other words, the knowledge gained of the export market by the industry is

and Venables (2007), highlight the complexity of the spatial relationships of economic activity that determine trade patterns.

[9] Also, due to the backward and forward linkages of production, spatial effects may tend to persist and grow over time.

[10] See Greenaway and Kneller (2007) for a review of the relevant litterature.

[11] The magnitude of the persistence coefficient varies across countries. Greenaway and Kneller (2007) show that participation increases the probability that a firm will continue to export by between 36 percent in the US (Bernard and Jensen, 2004a) and 90 percent in Italy (Bugamelli and Infante, 2002).

easily transferable to firms within the industry. Logically, firms will also face lower sunk costs of entering if, other things remaining equal, the firms export to specific markets that are already served by other firms' exports.[12]

Some studies on the effects of the euro on trade, including those of De Nardis et al. (2008), Bun and Klaasen (2007) and Berger and Nitsch (2008), attempt to address the issue of persistence. De Nardis et al. (2008) estimate a dynamic panel version of the gravity model. Bun and Klaasen (2007) include a separate time trend for each country pair and perform OLS and Dynamic OLS estimation. Berger and Nitsch (2008) extend the trade data back to 1948, include a common time trend for the development of trade, and estimate a gravity regression using OLS. The common feature of these studies is either the lowering of the effect of the euro on trade, or (as in the case of Berger and Nitsch (2008)), its eradication. However, as Baldwin et al. (2005) point out, including ad hoc time trends is not the most satisfactory empirical approach with which to deal with the issue.[13] Our approach is to incorporate both country pair and time fixed effects, as well as time autocorrelation in the errors specific to each exporter.

Another issue common to most papers that employ gravity estimations is the issue of endogeneity.[14] Gravity regressions typically include an explanatory variable for the size of the market for both the exporter as well as the importer. These variables are usually proxied by the GDP of the respective countries. However, since trade is a component of GDP, it should be viewed as endogenous. A straight-forward way to deal with this issue is to include a measure net of trade. Surprisingly, however only a few studies do this. We choose a different approach that of instrumental variables. An advantage of our approach, is that it can be used more generally in estimation.

Finally, we take into account that countries may react differently to identical shocks, i.e. the parameters of the error process are country specific. These parameters relate to both spatial and time autocorrelation, as well as to the country specific variances. These specifications could reflect differences in the structure of production in between economies, the efficiency of the public sector, or differences in the development of the financial sector among countries. The above mentioned issues suggest that typical gravity models suffer from a variety of miss-specifications

[12] These results suggest that bilateral trade might also exhibit persistence.

[13] Baldwin et al.'s criticism of the use of time trends applies to the studies by Berger and Nitsch (forthcoming) and Bun and Klaasen (2007). The findings of de Nardis et al. (2008) are are subject to the criticism that those authors control only for country effects (and not country-pair effects) and because they use the log of the sum.

[14] We refer to endogeneity apart from the potential endogeneity of the currency union itself. See Barr et al. (2003).

and so their corresponding estimation results are biased.[15]

3 Our model

3.1 The variables

Our starting point for the specification of the gravity model comes from the study of Flam and Nordström (2006a), considered by Baldwin (2006, p. 38) to be "... probably the best paper in the field to date" in terms of estimation methodology.

We use direction-specific bilateral trade flows, in this case exports from country (i) to country (j) deflated by the producer price index of the exporter (country i), as our dependent variable. The countries included are a relatively homogenous group comprising the EU-15 countries (since trade statistics for Belgium and Luxembourg are reported as one country, it is more correct to say the EU-14), as well as the USA, Canada, Norway and Switzerland, i.e. we have $18 * 17 = 306$ country-pairs; our data relate to the years $1989 - 2006$. Our explanatory variables include the exporter's GDP as a measure of export supply capacity and the distance deflated GDP of the importer as a measure of import demand. We note that the GDPs of exporters and importers involve exports and hence are endogenous. We expand the traditional gravity regression by including a distance weighted average of the real GDPs of other potential exporters, as well as a distance weighted average of the real GDPs of other potential importers, so that we account for demand and supply factors of "third" countries.

As in Flam and Nordström (2006a), the use of exports as the dependent variable makes it necessary to take account of changes in real exchange rates. We consider both the bilateral real exchange rate, and the average of "third" countries' real exchange rates against the importing country. The "third" countries' real exchange rate can be seen as a competition effect, so that an appreciation of competitors' real exchange rates will favour the exporting country.[16]

Country pair and time fixed effects are included as well as a dummy for intra EU-membership effects on exports. As in Flam and Nordström, we include dummy

[15] These corrections will probably also mitigate what Baldwin et al. (2008) call the "Anderson and van-Wincoop misinterpretation" issue.

[16] Data for bilateral trade (exports) are from UN comtrade while bilateral distances are from CEPII. GDP, GDP deflators and exchange rates are from World Development Indicators. PPI data are from OECD. Exports and GDP data are expressed in real values at 2000 US$ exchange rates. Real bilateral exchange rates are calculated as the exchange rate of country (i) per US dollar deflated by the PPI of country (i) divided by the corresponding PPI deflated exchange rate (per US dollar) of country (j): $[(EX_i/US\$)\,/(EX_j/US\$)] * (PPI_j/PPI_i)$.

variables to control for the effects on measured trade of changes in the collection of trade statistics, as well as a dummy variable for the Uruguay round of trade liberalization.[17] Finally our main explanatory variables of interest are three dummy variables which relate to exports between euro countries, exports from euro to non-euro countries, and exports from non-euro to euro countries.

Table 1: Model Variables:

Dependent variable is Lrexp(i,j,t): Log of real exports at time t from country (i) to (j)	
Independent variables:	d_{ij} is the distance between countries i and j
$\mathbf{EMU}_t\mathbf{(11)}$	Dummy variable for exports between euro countries.
	Is 1 if (i) and (j) belong to EMU at time t, 0 otherwise
$\mathbf{EMU}_t\mathbf{(12)}$	Dummy variable for exports from euro to non-euro countries.
	Is 1 if (i) belongs to EMU and (j) does not at time t, 0 otherwise
$\mathbf{EMU}_t\mathbf{(21)}$	Dummy variable for exports from non-euro to euro countries. Its value is
	1 if (i) does not belong to EMU and (j) does at time t, 0 otherwise
$lGDP(i,t)$	Log of real GDP at time t of country i (exporting country)
$lGDP(j,t)/d_{ij}$	Log of real GDP at time t of country j $/d_{ij}$ (importing country)
$lGDP_{i,t}(cX)/W^{(+)}$	Log of average distance weighted sum of real GDP at time t
	of other exporters. (Surrounding market potential for exporters)
$lGDP_{j,t}(cIm)/W^{(+)}$	Log of average distance weighted sum of real GDPs at time t
	of other importers. (Surrounding market potential for importers)
$lRER(i,j,t)$	Log of bilateral real exchange rate at time t between (i) and (j)
$lRERave(cXj)$	Log of average real exchange rates at time t between
	other exporters and importing countries: A competition effect.
$EUmemb_{i,j,t}$	Dummy variable for intra EU-membership effects on exports.
	Is 1 if (i) and (j) belong to the EU at time t, 0 otherwise.
UR_t	Dummy variable for Uruguay Round liberalization 1995-2002
	between countries not in same free trade area.
$DnonEU_i - EU_{j,t}$	Dummy variable for exports from non-European countries to EU-countries.
	Is 1 if (i) is Non-European and (j) is EU at time t, 0 otherwise
$DnonEU - BeNe_t$	Dummy for exports from non-European countries
	to Belgium and Netherlands, 1 if $t \geq$1993, and zero otherwise
$D.BeNe_i - EU_j$	Dummy variable for exports from Belgium and Netherlands to EU-countries.
	Is 1 if (j) is an EU-country at time, t, and 0 otherwise
τ_t	Time fixed effects
μ_{ij}	Country pair fixed effects

$^{(+)}$ In general, let there be n countries, and let $GDP(i,t)$ be the real GDP of country i at time

[17] The six control variables that Flam and Nordström (2006a) use are condensed to three. Also, instead of using separate time dummies common for the EU countries as in Flam and Nordström, we include a time-varying dummy variable to capture intra-EU effects.

t. Recall that in our sample $n = 18$.[18] Then, corresponding to the variable $Lrexp(i, j, t)$

$$\begin{aligned} lGDP_{i,t}(cX)/W &= Log(\frac{1}{n} \sum_{\substack{r=1 \\ (r \neq i; r \neq j)}}^{n} GDP(r,t)/d_{ri} \\ lGDP_{j,t}(cIm)/W &= Log(\frac{1}{n} \sum_{\substack{r=1 \\ (r \neq i; r \neq j)}}^{n} GDP(r,t)/d_{rj} \end{aligned}$$

So, loosely speaking, our model consists of homogenous countries, where we control for country pair time invariant effects, as well as common time effects. We also control for direct demand and supply effects as well as spatial demand and supply effects. Finally we control for real exchange rate effects, competition effects, common EU-effects, and for the timing the Euro was introduced. Since the direct demand and supply effects are endogenous, we use an instrumental variable method to estimate our model.

3.2 The spatial specification

Let x_{ij}^t be exports from country i to j at time t, and let z_{ij}^t be the $1 \times k$ vector of explanatory variables for x_{ij}^t as described in Table 1 except for the country pair fixed effects - i.e. $k = 32$.[19] Let μ_{ij} be the country pair fixed effect between these countries. For purposes of generality, let there be n countries.

Let X_i^t be the $n-1 \times 1$ vector of exports of country i to all the other $n-1$ countries at time t:

$$X_i^{t\prime} = \left[\begin{array}{cccccccc} x_{i1}^t, & . & . & . & x_{i,i-1}^t, & x_{i,i+1}^t, & . & . & . & x_{in}^t \end{array} \right]_{1 \times n-1} \quad ; \; i = 1, ..., n \qquad (1)$$

and let Z_i^t be the corresponding $n-1 \times k$ matrix of observations on z_{ij}^t. Similarly, let μ_i be the $n-1 \times 1$ vector of fixed effects:

$$\mu_i' = \left[\begin{array}{cccccccc} \mu_{i1}, & . & . & . & \mu_{i,i-1}, & \mu_{i,i+1}, & . & . & . & \mu_{in} \end{array} \right]_{1 \times n-1}$$

In our development below we will assume that the GDP variables of the exporters and importers, namely $lGDP(i, t)$ and $lGDP(j, t)/d_{ij}$ described in Table 1, are endogenous.[20]

[18] The fact that country (i), and country (j) are located at different points in space, ensures that the spatially lagged GDP's, $lGDP_{i,t}(cX)/W$ and $lGDP_{j,t}(cIm)/W$, differ from each other.

[19] Excluding the country pair fixed effects, there are 14 regressors listed in Table 1 and 18 dummy variables representing the time fixed effects (14+18=32).

[20] In fact, since the GDP's of country (i) and (j) includes the exports of (i) to (j), either as exports or as imports, they are endogenous. On the other hand the spatially lagged GDP variables are not endogenous, for the same reason.

Given this notation our model for X_i^t is

$$X_i^t = \mu_i + Z_i^t B + U_i^t,\ t = 1, ..., T \tag{2}$$

where, using evident notation, U_i^t is the corresponding vector of disturbances:

$$U_i^{t\prime} = \begin{bmatrix} u_{i1}^t, & . & . & . & u_{i,i-1}^t, & u_{i,i+1}^t, & . & . & . & u_{in}^t \end{bmatrix}_{1\times n-1} \ ;\ i = 1, ..., n$$

For future references we express (2) in terms of the dummy variables which implicitly correspond to the fixed effects:

$$X_i^t = I_{n-1}\mu_i + Z_i^t B + U_i^t,\ i = 1, ..., n;\ t = 1, ..., T \tag{3}$$

We assume that the regression disturbances, U_i^t, are both spatially and time autocorrelated. Specifically, let $W_i, i = 1, ..., n$ be an $n-1 \times n-1$ weighting matrix which is defined below. In our model framework W_i is exogenous. Using evident notation, our assumptions concerning the disturbance vectors are

$$\begin{aligned} U_i^t &= \alpha_i U_i^{t-1} + \varepsilon_i^t \\ \varepsilon_i^t &= \rho_i W_i \varepsilon_i^t + \psi_i^t \\ i &= 1, ..., n;\ t = -2, -1, 0, 1, ... \end{aligned} \tag{4}$$

where

$$\begin{aligned} E\psi_i^t \psi_i^{t\prime} &= \sigma_i^2 I_{n-1} \\ E\psi_i^t \psi_j^{s\prime} &= 0,\ \text{unless } t = s \text{ and } i = j. \end{aligned} \tag{5}$$

The specifications in (4) and (5) describe the time autocorrelation as a first order AR process whose innovations are spatially correlated as a first order spatial process- see, Anselin (1988) and Kelejian and Prucha (2004). That spatial process varies across countries because its parameters, α_i, ρ_i, and σ_i, vary across countries.

Note that the specifications in (4) and (5) imply that $\varepsilon_i^t = (I - \rho_i W_i)^{-1}\psi_i^t$ and so the variance-covariance matrix of ε_i^t, say $VC_{\varepsilon_i^t}$ is

$$VC_{\varepsilon_i^t} = \sigma_i^2 (I - \rho_i W_i)^{-1}(I - \rho_i W_i')^{-1} \tag{6}$$

Therefore, among other things, the innovation vector ε_i^t in the time autoregressive process is heteroskedastic across countries even if $\rho_i = 0$ since the variances σ_i^2 vary across countries. It should also be clear that if $\rho_i \neq 0$ the elements of the innovation vector ε_i^t will be heteroskedastic within each country because the diagonal elements of the matrix $(I - \rho_i W_i)^{-1}(I - \rho_i W_i')^{-1}$ will not all be the same.

Consider now the weighting matrix, W_i. As in all weighting matrices, we take its diagonal elements to be zero. We specify off diagonal element, say w_{rs}^i, $r \neq s$, as

$$w_{rs}^i = \frac{1}{d_{rs}} \tag{7}$$

where again d_{rs} is the distance between country (r) and country (s). This specification suggests that the extent of spatial correlation between the error terms in the equations explaining exports from country (i) to country r, and exports from country (i) to country (s) is inversely related to the distance between countries (r) and (s). One rational for this would be export cost considerations relating country (i) to the countries it is exporting to, namely (r) and (s). As an illustration of the specification, suppose $n = 5$. Then W_1 would be

$$W_1 = \begin{bmatrix} 0 & 1/d_{23} & 1/d_{24} & 1/d_{25} \\ 1/d_{23} & 0 & 1/d_{34} & 1/d_{35} \\ 1/d_{24} & 1/d_{34} & 0 & 1/d_{45} \\ 1/d_{25} & 1/d_{35} & 1/d_{45} & 0 \end{bmatrix}$$

4 Estimation

We estimate our model by an iterative procedure. Specifically, we first pool the data over all the countries and time periods, and then use an IV procedure to estimate B and the fixed effects, $\mu = (\mu_1', ..., \mu_n')$. We then obtain the residuals and use them to estimate the time and spatial autoregressive parameters, $\alpha' = (\alpha_1, ..., \alpha_n)$ and $\rho' = (\rho_1, ..., \rho_n)$, as well the country variances $\sigma^{2\prime} = (\sigma_1^2, ..., \sigma_n^2)$. We then transform the model to account for the time and spatial autocorrelation, and also for the country variances. This transformed model is again estimated by an IV procedure. Further details are given in the appendix.

4.1 Regression parameter estimation results

As indicated, our estimation procedure is an iterative one, the steps of which correspond to corrections for statistical problems. As such, one advantage of the estimator developed here is that we can estimate most steps separately and so we can see how the various corrections influence the results. In Table 2 we report the main empirical results corresponding to these corrections.

Column (1) in Table 2 reports the OLS estimation of our model. These results are presented because the OLS procedure is typically applied in the literature to gravity models such as ours.[21] This procedure does not account for endogeneities, nor for the specification problems relating to our error terms. Therefore, the regression parameter estimates and their standard errors given in column (1) are not consistent. These results are given only for purposes of comparison to those in the literature. Below we compare these results to our final model estimates and make clear that reliance on inappropriate procedures can clearly lead to "inappropriate" conclusions.

Perhaps not surprisingly,[22] the OLS estimates given in column (1) are, by-and-large, in line with what is generally found in the literature. For example, the intra-euro area [$EMU(11)$] effect is estimated at 0.062, which is at the lower end of the range found in previous studies. This estimate also "appears" to be significant at the two-tail 1 per cent level. The OLS estimated effect of exports from non-euro-area countries to euro-area countries [$EMU(21)$] is also positive (at 0.071) and, again, appears to be significant at the 1% level. The estimated effects of the GDPs of exporter (i) and importer (j) (i.e., $LGDP(i)$ and $LGDP(j)/Dist(ij)$, respectively) are both positive and seemingly significant, and both coefficients are near unity. The bilateral real exchange rate variable $LRER(ij)$ is positive and seemingly significant, suggesting that if the real bilateral exchange rate of country (i) relative to country (j) depreciates, i.e. $LRER(ij)$ increases, country (i)'s exports to country (j) increase. The real exchange rate of other exporters, $LRERave(cXj)$, is negative and seemingly significant, so that the suggestion is that a depreciation of this rate decreases the exports of country (i), as one would expect. The difference in magnitude between these two real exchange rate measures indicates, as in Flam and Nordström (2006a), some degree of product differentiation. Finally, in line with the previous literature, the estimated effect of EU-membership, $EUmemb$, is positive and apparently significant effect on country (i)'s exports.

The results in column (2) relate to the (ordinary) $2SLS$ estimation of our model. Because this is an IV procedure which accounts for the endogenous variables in our

[21] The main difference between the typical model in the literature and our model is that the typical model in the literature does not include variables reflecting third country effects- e.g., our spatially weighted GDP's of other exporters and importers.

[22] In fact the inlcusion of our 'third' country variables does not have a significant impact on the magnitude and significance of other explanatory variables in the OLS estimation.

model, the regression parameter estimates in this column are based on a consistent procedure. However, because the statistical problems of the error terms are not accounted for, the standard errors given in column (2) are not consistent. The third column gives results which relate to an IV estimation procedure of our model which account for all its complications except for the time correlation of its error terms. Therefore, unlike for the regression parameter estimates, the standard errors given in column (3) are not based on a consistent procedure. Finally, the fourth column in Table 2 gives results which account for all of our model specifications, and so proper inferences should be based on these results.

Looking across the columns, it is evident that unless time autocorrelation of the error terms is accounted for, the estimate of the regression coefficient of $EMU(11)$, as well as its level of significance will be overstated. Clearly, the same comments apply to the results corresponding to the variables $EMU(21)$, $EUmemb$, and $LGDP(cX)/W$. In passing we note that the results in columns $(1)-(3)$ corresponding to $EMU(11)$, $EMU(21)$, and $EMUmemb$ are quite similar.

Comparing the results from column (1) with those of column (4), which are based on our final estimator and are thus should be used to make inferences, we see that the differences are sizeable. The intra-euro effect ($EMU11$) is only 0.043 and is significant only at the 10% level. The coefficient of the variable representing exports from non-euro area countries to euro-area countries ($EMU21$), at 0.031, is also much lower in magnitude, compared with the OLS, estimate and only marginally significant at the 10 per cent level.

Table 2: Regression Parameter Estimates : 1989-2006

Dependent variable:Log of Real Bilateral Exports Lrexp(ij) from (i) to (j)				
	(1) OLS	(2) 2SLS	(3) IV, No TA[&]	(4) Final Estimator
EMU(11)	0.062***	0.072***	0.064***	0.043*
	(3.66)	(4.03)	(3.69)	(1.83)
EMU(12)	0.011	0.026	0.048***	0.036
	(0.65)	(1.49)	(2.78)	(1.49)
EMU(21)	0.071***	0.065***	0.066***	0.031*
	(4.19)	(3.67)	(5.23)	(1.87)
LGDP(i)	0.91***	0.61***	0.30***	0.53***
	(22.00)	(11.46)	(2.36)	(12.96)
LGDP(j)/Dist(ij)	0.98***	1.03***	0.97***	0.77***
	(23.55)	(19.42)	(29.61)	(65.86)
LGDP(cX)/W	1.95***	1.62***	1.00***	0.001
	(7.96)	(6.27)	(5.92)	(0.09)
LGDP(cIm)/W	−3.19***	−2.94***	−3.37***	−0.34***
	(12.72)	(11.08)	(10.14)	(4.15)
LRER(ij)	0.90***	0.88***	0.78***	0.44***
	(20.89)	(19.51)	(14.56)	(7.40)
LRERave(cXj)	−0.52***	−0.50***	−0.54***	−0.31***
	(8.74)	(8.07)	(9.45)	(5.45)
EUmemb	0.072***	0.072***	0.072***	0.01
	(5.13)	(4.90)	(7.46)	(1.04)
D. UruRound	−0.01	−0.03	0.00	−0.05**
	(0.62)	(0.17)	(0.00)	(2.37)
D. BeNe-EU	0.046**	0.044*	0.065***	0.07***
	(1.93)	(1.74)	(3.31)	(3.00)
D nonEU-BeNe	0.03	0.03	−0.01	0.01
	(0.77)	(0.76)	(0.21)	(0.35)
D nonEU-EU	0.05**	0.047**	0.004	0.01
	(2.55)	(2.33)	(0.22)	(0.35)
R2-within	0.71	0.69	0.70	0.89
Obs.	5375	5375	5375	5069

[&]Column (3) only accounts for endogeneity, spatial autocorrelation, and heteroscedasticity across countries.

*,** ,*** denote significance at the 10-%, 5-% and 1-% confidnce level respectively, t-stat in parenthesis.

In column (4) the coefficient on the exporter's GDP, measuring export supply capacity, is about one half of that found for column (1). Likewise the GDP of the importer ($LGDP(j)/Dist(ij)$) is also substantially lower than the OLS estimates. In fact, the coefficients of both of these variables given in column 4 are significantly lower than unity.[23] The spatially-weighted GDPs of other exporters $((LGDP(cX)/W))$ is now insignificant, which is in line with our expectations.[24] Note, that the positive OLS estimate would imply that if other competing exporters (s) increase their export supply capacity/market size, country (i) will increase its exports to country (j). Fortunately, these results are the product of the biases inherant in the OLS procedure and shows that if we did not account for statistical complications, we would be left with inconsistent and counterintuitive estimates.. Moving on, we notice that the variable representing spatially-weighted GDPs of other importers $((LGDP(cIM)/W))$ remains negative and significant, but its magnitude is only about one-tenth of column (1) indicating much smaller effects of export diversion.[25]

The coefficient on the bilateral exchange rate variable $LRER(ij)$, while still positive and highly significant, is about one-half the value of the OLS estimates. The real exchange rate of other exporters, $LRERave(cXj)$, is also still negative and significant, but with a much lower point estimate. The results on the real exchange rate variables of our final estimator indicate that the exchange rate pass-through is not as large as we may have thought based on our OLS results. In addition, since the difference between the two variables, in column (4), is much smaller compared with the OLS estimates, there seems to be a lower effect of product differentiation, indicating perhaps stronger competition effects from other exporters. Finally, we can note that the coefficient on the EU-membership variable $(EUmemb)$ is essentially zero and insignificant. Note that one would be lead to believe that EU-membership is a significant determinant of exports if one did not account for the endogenous variables in our model (column (1)), or for the time series correlation of the error terms, columns (2) and (3).[26]

Our results in Table 2 show clearly that the differences between what is commonly estimated in the literature and our final estimator are substantial. In most cases the largest changes in both the estimated coefficients and their t-ratios occurs when time autocorrelation is accounted for. Thus, our results suggest that if statistical com-

[23] The instrument set used for the GDP of country (i) and the GDP of country (j) respectively, is comprised of: 1) all available inside instruments and 2) outside instruments defined as the log of: a) total population, b) land area, c) researchers in R&D (per million people), d) stocks traded, e) final consumption by general government and f) number of scientific journals. First step estimates are highly significant for all IV-estimations.

[24] The expectations for this third country variable is to be either insignificant or negative and significant.

[25] That is, for exports from country (i) to country (j), if other importers (cIM) increase their market size, i.e. their import demand, then country (i) will export somewhat less to country (j) (and export somewhat more to these other countries).

[26] This is not to say that the common market had no effect on trade, but rather that the effects on trade from further integration can not be easily delineated by a specific date.

plications are not accounted for and in particular the issue of time autocorrelation, we would be left with biased, inconsistent and counterintuitive result.

4.2 Time and spatial autoregressive parameters, and country specific variances

As should be clear from the above, unless complicating statistical characteristics of models such as ours are accounted for, researchers will typically be lead to erroneous conclusions concerning the effects of certain variables. In this section, we give results which strongly indicate that these "statistical complications" are indeed real and so should not be ignored.

Figure 1 describes the three "complicating factors" relating to our error term. These factors are the parameters in the time and spatial autoregressive processes, namely α_i and ρ_i, and the country specific variances, σ_i^2 (i.e., cross-equation heteroscedasticity). The scale for the autoregressive parameters, ρ_i and α_i, is the left-hand vertical axis, while the scale for the variances σ_i^2 is the right-hand vertical axis. The numerical estimates of these parameters are given in Table 3.

The results in Figure 1 strongly suggest that the parameters of the disturbance process are not constant across countries. This is especially the case for σ_i^2 but also for the autoregressive parameters, α_i and ρ_i . For example, the variance corresponding to Canada is more than 10 times larger than that for Italy. The spatial autoregressive parameter ρ_i for Belgium-Luxembourg is more than 4.5 times larger than that for Canada, while the time autoregressive parameter, α_i, for Ireland is more than twice that the Netherlands. It is also interesting to note that for some countries the extent of spatial and time correlation are both high, while for others, one is high and the other is low. An example of the former is Belgium-Luxembourg, while an example of the latter is Ireland. Thus, for example, for Belgium-Luxembourg, exports to other countries at a point in time have a high spatial component, and exports to a particular country have a high persistence level over time. However, exports from Ireland to other countries have a fairly low spatial component, perhaps because Ireland is an island, but exports from Ireland to a particular country have a high persistence level over time.

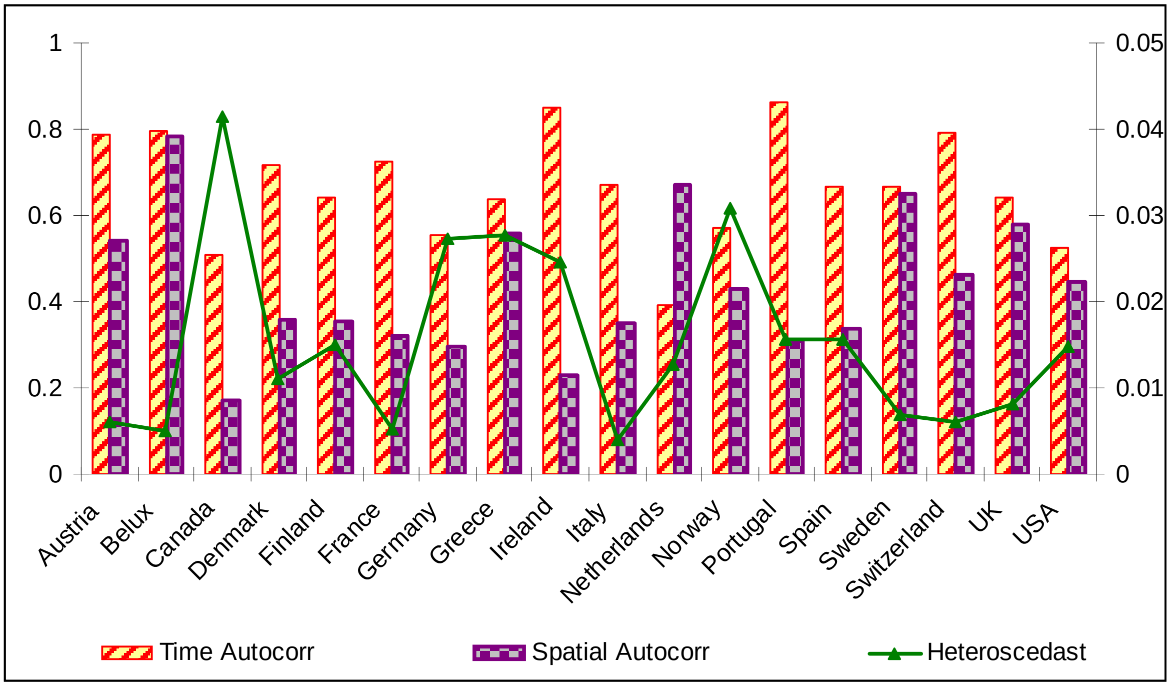

Figure 1: Country specific parameter estimates

Finally, in Table 3 we see that the average of the estimated time autoregressive parameters, α_i, is .666, which is reasonably high. This may help to explain why changes in the estimated effects of aggregate time-shifting variables, such as $EMU(11)$, $EMU(21)$ and EU memberships on trade are quite pronounced when time autocorrelation is accounted for than when it is not - compare column 4 to the other columns in Table 2. In comparing columns 2 and 3 in Table 2, however, we see that the results change to a lesser extent when spatial correlation is accounted for. Of course, one reason for this result is that the average of the estimated spatial autoregressive parameters, ρ_i, given in Table 3 is .436, which is only two thirds of average of the time autoregressive parameters.[27]

One might wish to explain the estimated values of the parameters in the error process, α_i, ρ_i and σ_i^2. However, by construction, the error process of a model reflects the net sum of *all* relevant factors that the model does not account for. Therefore simple explanations could be misleading. For example, consider the estimates of the spatial parameters, ρ_i given in Table 3. It would appear that countries which have nearby trading partners should have the largest values of this parameter. Three such countries that fall into this category are Belgium-Luxembourg, Netherlands,

[27] All esimated time autoregressive parameters were highly significant. For the spatial autoregressive parameters the GM estimation does not produce standard errors.

and Sweden, which have the highest estimated values of ρ_i. That there may be more to the story should be clear by noting that Canada has the lowest estimated value of ρ_i even though 90 percent of its exports (in the sample) go to the US, and all of its other trade-partners have a bare minimum of trade, irrespective of distance. Similarly, Ireland has the second smallest estimated value of ρ_i even though it has a major close-by trading partner, namely the UK, while its other major trading partners are a mixture of somewhat more distant countries, as well as a far off country, namely the US. If distance were the determining factor in explaining the value of the spatial parameters, the value of ρ_i for Ireland would be larger.[28]

Table 3: Country specific parameter estimates

	Time autocorrelation	Spatial Autocorrelation	Spatial Heteroscedasticity
Exporter	α_i	ρ_i	σ_i^2
Austria	0.787	0.547	0.006
Belgium-Lux.	0.796	0.794	0.005
Canada	0.507	0.170	0.042
Denmark	0.718	0.365	0.011
Finland	0.643	0.359	0.015
France	0.723	0.323	0.005
Germany	0.556	0.302	0.027
Greece	0.637	0.558	0.028
Ireland	0.849	0.230	0.024
Italy	0.669	0.355	0.004
Netherlands	0.390	0.674	0.013
Norway	0.569	0.431	0.031
Portugal	0.861	0.311	0.016
Spain	0.668	0.339	0.016
Sweden	0.666	0.649	0.007
Switzerland	0.792	0.468	0.006
UK	0.642	0.584	0.008
USA	0.523	0.452	0.015
Mean	0.666	0.436	0.015
St.Dev	0.126	0.164	0.011

The rest of the countries in the table have somewhat more intermediate estimated

[28] In fact Sweden, Belgium-Luxembourg and Netherlands all have several major trading partners close by, while other countries only have one.

values of ρ_i. These countries, to a varying degree, have one major trading partners that are close-by. Their other trading partners, while not near-by are not major trading partners, but they are not small either; in some cases their importance declines with distance while in other cases it does not. Clearly, taken together, the discussion above suggests that there are factors in addition to distance which determine the values of the spatial parameters ρ_i.

Similar comments apply to the values of the other parameters of the error process. As one example, one might assume that the value of the country variance parameter, σ_i^2, should be related to a measure of the size of the country, or its exports. However, in Table 3 we see that the estimated value of this parameter for the US is half the size of that for (the much smaller) Norway. Similar issues would of course occur if one attempts to interpret the country specific estimates of time autocorrelation α_i. All of this suggests that one should not explain the parameters of the error process in "intuitive" ways - i.e., they are the unexplained part of the model.

5 Conclusions

In this paper we study the effects of the introduction of the euro on trade. In doing this we account for various statistical complications that are often ignored, and have a strong influence on the results. Previous research has produced a wide range of estimates concerning the effects of the euro on trade. To name but a few : Micco et al. (2001) obtain an effect of around 10 percent, Flam and Nordström (2006a) an effect of around 16 percent, Baldwin et al. (2005) an effect of 70 percent or more, Baldwin and di Nino (2006) 10-15 percent on aggregate data. In the literature, studies that account for dynamic effects generally tend to report lower estimates of the effects of the euro on trade. Some examples are Bun and Klaasen (2008) who report an effect of 3 percent, Viccareli et al. (2008) report an effect of 5 percent, and finally Berger and Nitsch (2008) who find no effect when they use an extended sample from 1948-2003, although those same authors find a 5 percent effect for the sample 1992-2003.

Based on recent theoretical and empirical findings we assume that trade is spatial in nature and persistent over time. These issues, as well as others, are typically not accounted for in a satisfactory way when specifying trade regressions. To estimate the parameters of our model we develop an iterative procedure which accounts for fixed effects, as well as endogeneities, time-autocorrelation, spatial autocorrelation, and heteroscedasticity across countries. We also account for third country effects in estimating the effects of the introduction of the euro on trade.

Our results quite-strongly indicate that statistical complications in models such as ours should not be ignored. For example, if our model is estimated by OLS, which is frequently used in the literature, the estimated effect of the introduction of the euro on trade is 6.4 per cent, which is at the lower end of the range of previous research. However, we find that when statistical complications are accounted for, our estimate of that effect is only 4.3 per cent. It also turns out that accounting for statistical complications has a large effect on the significance level of many of our model estimates. As an example, if statistical complications are not accounted for we would be led to believe that EU membership has a significant and positive effect on trade; however, when statistical problems are accounted for, the coefficient of the EU membership variable is no longer significant. In addition, if statistical problems are ignored, one could be left with statistically significant but counterintuitive result, such as if the GDP of "third country" competing exporters increases, the exports of a given exporter also increases. On the other hand, once statistical complications are accounted for, the GDP of "third country" competing exporters is no longer a significant variable and so there are no counterintuitive results to explain.

As a summary, our results suggest that the effects of currency unions on trade as described in the previous literature has been greatly overstated. In addition, if various and evident statistical complications are not accounted for, empirical results based on trade models may be very misleading.

References

[1] Anselin, L. 1988. Spatial econometrics: Methods and models. Dordrecht, the Netherlands: Kluwer.

[2] Baldwin R, Di Nino V., 2006. "Euros and Zeros: The Common Currency Effect on Trade in New Goods", NBER Working Paper No. W12673

[3] Baldwin R., 2006. "The euro's trade effects", ECB Working Paper No.594.

[4] Baldwin R., De Santis R., Di Nino V., Fontagné L., Taglioni D., 2008. "Study on the Impact of the Euro on Trade and Foreign Direct Investment", European Commission - Economic Papers No. 321|

[5] Baldwin R., Skudelny F., Taglioni D., 2005. 'Trade Effects of The Euro: Evidence from Sectoral Data', ECB Working Paper No. 446.

[6] Baltagi B.H., Egger P., Pfaffermayr M., 2007. "Estimating models of complex FDI: Are there third-country effects?," Journal of Econometrics, 140(1), pp. 260-281.

[7] Baltagi B.H., Egger P., Pfaffermayr M., 2008. "Estimating regional trade agreement effects on FDI in an interdependent world," Journal of Econometrics, 145(1-2), pp.194-208.

[8] Barr D., Breedon F., Miles D., 2003. "Life on the Outside" Economic Policy, 18, pp. 573 - 613.

[9] Berger H., Nitsch V., 2008. "Zooming out: The trade effect of the euro in historical perspective," Journal of International Money and Finance, 27(8), pp.1244-1260

[10] Bernard, A. and Jensen, J.B. 2004. "Why some firms export", Review of Economics and Statistics, vol. 86, pp. 561–569.

[11] Blonigen, B.A., Davies, R.B., Waddell, G.R., Naughton, H.T., 2007. "FDI in space", European Economic Review, 51, pp.1303-1325

[12] Bugamelli, M. and Infante L. 2002. "Sunk costs to exports", Bank of Italy Research Papers.

[13] Bun M., Klaassen F. 2007. “The Euro Effect on Trade is not as Large as Commonly Thought”, Forthcoming on the Oxford Bulletin of Economics and Statistics, 69, pp. 473-496.

[14] De Grauwe, P., 2007. Economics of Monetary Union. Oxford, U.K.: Oxford University Press

[15] De Nardis S., De Santis R., Vicarelli C., 2008. “The Euro’s Effects on Trade in a Dynamic Setting”, The European Journal of Comparative Economics, 5, pp. 73-85

[16] Flam, H., Nordström H., 2006a. "Trade Volume Effects of the Euro: Aggregate and Sector Estimates", IIES Seminar Papers No. 746

[17] Flam, H., Nordström H., 2006b.“Euro effects on the intensive and extensive margins of trade,” IIES Seminar Papers No. 750

[18] Frankel J. A., Rose A. K., 1998. "The Endogeneity of the Optimum Currency Area Criteria", The Economic Journal, 108(449), pp.1009-1025.

[19] Frankel, J. Rose A., 2002, “An estimate of the effect of currency unions on trade and output”, Quarterly Journal of Economics, 108 (441):1009-25.

[20] Glick R., Rose A., 2002. "Does a Currency Union Affect Trade? The Time Series Evidence", European Economic Review, 466, pp.1125-1151.

[21] Greenaway, D., Kneller, R., 2007. "Firm heterogeneity, exporting and foreign direct investment ", Economic Journal 117, F134–F161.

[22] Grossman G.M., Helpman, E., Szeidl, A., 2006. Optimal integration strategies for the multinational firm. Journal of International Economics, 70, pp.216-238.

[23] Hall S.G., Petroulas P., 2008. “Spatial Interdependencies of FDI Locations: A Lessening of the Tyranny of Distance?”, Bank of Greece Working Paper No. 67.

[24] Kelejian, H.H., Prucha, I.R., 2004. “Estimation of systems of spatially interrelated cross sectional equations”, Journal of Econometrics, 118, pp. 27-50.

[25] Markusen J.R., Venables A.J., 2007. Interacting factor endowments and trade costs: a multi-country, multi-good approach to trade theory. Journal of International Economics, 73, pp.333-354.

[26] Melitz M., 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. Econometrica 71, pp.1695–1725.

[27] Micco A., Stein E., Ordonez G., 2003. "The Currency Union Effect on Trade: Early Evidence From EMU", Economic Policy, pp.316-356.

[28] Nitsch, V., 2002. "Honey I Shrunk the Currency Union Effect on trade", World Economy 25-4, pp 457-474.

[29] Persson, T., 2001, "Currency Unions and Trade: How Large is the Treatment Effect?", Economic Policy, 33, pp 435-448.

[30] Rose A. K., 2000. "One Money, One Market: the Effect of Common Currencies on Trade", Economic Policy 30, April, pp. 7-45

[31] Rose A., Van Wincoop E. 2001. 'National Money as a Barrier to International Trade: The Real Case for Currency Union', American Economic Review, 912, pp.386-390.

[32] Rose, A., 2008. "EMU, Trade and Business Cycle Synchronization", paper presented at the European Central Bank conference on The Euro of Ten: Lessons and Challenges, Frankfurt, Germany, November 13-14.

[33] Rossi-Hansberg E., 2005. "A Spatial Theory of Trade", American Economic Review, 95:5, pp.1464-1491

Appendix: The Estimation Procedure

To express our model in stacked form, let

$$X_i' = [X_i^{1\prime}, ..., X_i^{T\prime}];\ Z_i' = [Z_i^1, ..., Z_i^{T\prime}];\ U_i^{'} = [U_i^{1\prime}, ..., U_i^{T\prime}]$$

Then, in stacked form the regression model in (4) can be expressed as

$$\begin{aligned} X &= diag_{i=1}^n[e_T \otimes I_{n-1}]\mu + ZB + U \qquad (8) \\ &= Q\gamma + U; \\ Q &= [diag_{i=1}^n[e_T \otimes I_{n-1}], Z] \end{aligned}$$

Let Z^* be identical to Z except that it does not contain the two columns in Z which relate to the two endogenous GDP variables, namely $lGDP(i,t)$ and $lGDP(j,t)/d_{ij}$. Also, we take G to be our matrix of instruments where

$$G = [diag_{i=1}^n[e_T \otimes I_{n-1}], Z^*, K]$$

where K is a correspondingly stacked matrix of observations on six "outside" instruments. These instruments are: the log of: total population, area, researchers in R&D (per million people). stocks traded, final consumption by general government and number of scientific journals.

Given this notation, we estimated our model as described below. Calculation simplifications can be obtained by writing to the authors.

Step 1: The model in (8) is first estimated by 2SLS and, using evident notation, the residuals are estimated as $\hat{U} = X - Q\hat{\gamma}$.

Step 2: Again, using evident notation, the time autoregressive parameters are then estimated as

$$\hat{\alpha}_i = [\sum_{t=2}^{T} \hat{U}_i^{t-1\prime}\hat{U}_i^{t-1})^{-1}]\sum_{t=2}^{T} \hat{U}_i^{t-1\prime}\hat{U}_i^{t}\ ;\ i = 1, ..., n \qquad (9)$$

Step 3: The innovations to the time autoregressive process, namely ε_i^t, are then estimated as $\hat{\varepsilon}_i^t = \hat{U}_i^t - \hat{\alpha}_i\hat{U}_i^{t-1}, i = 1, ..., n;\ t = 2, ..., T$, and used to estimate the spatial autoregressive parameters, $\rho_1, ..., \rho_n$ by the GMM procedure in suggested by Kelejian and Prucha (1999) -see, e.g., (4). Note that the number of observations involved in the estimation of these autoregressive parameters is $(T-1)(n-1)$.

Step 4: The estimation of country specific variances, $\sigma_1^2, ..., \sigma_n^2$ are then obtained as

$$\sigma_i^2 = \sum_{t=2}^{T} \hat{\psi}_i^{t\prime} \hat{\psi}_i^t / (T-1)(n-1); \; i = 1, ..., n \tag{10}$$

where $\hat{\psi}_{i.}^t = \hat{\varepsilon}_i^t - \hat{\rho}_i W_i \hat{\varepsilon}_i^t$.

Step 5 (**The final estimator of** B) : The model in (8) is transformed to account for time and spatial autocorrelation, as well as for country specific heteroskedasticly, and then re-estimated by 2SLS. The instruments used in this step are all the columns of the transformed regressor matrix Q except for the two columns that correspond to the endogenous GDP variables, as well as the "outside" instruments discussed above which have also been transformed in the same manner as the columns of Q.

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