DB Nr. 77

Augmented gravity model: An empirical application to Mercosur-European Union trade flows

Inmaculada Martínez-Zarzoso
Felicitas Nowak-Lehmann D.

Abstract

This paper applies the gravity trade model to assess Mercosur-European Union trade, and trade potential following the agreements reached recently between both trade blocks. The model is tested for a sample of 19 countries, the four formal members of Mercosur plus Chile and the fifteen members of the European Union. A panel data analysis is used to disentangle the time invariant country-specific effects and to capture the relationships between the relevant variables over time. We find that the fixed effect model is to be preferred to the random effects gravity model. Furthermore, a number of variables, namely, infrastructure, income differences and exchange rates added to the standard gravity equation, are found to be important determinants of bilateral trade flows.

JEL classification: F14;

Key words: Gravity equation panel data infrastructure integration

1. Introduction

This paper explores the determinants of bilateral trade flows between European Union (EU) and Mercosur countries in the recent past. A gravity model of international trade is empirically tested to investigate the relationship between the volume and direction of international trade and the formation of regional trade blocks where members are in different stages of development. Furthermore, the standard gravity model is augmented with a number of variables to test whether they are relevant in explaining trade. These variables are infrastructure endowments, squared differences in per capita incomes and real exchange rates. Finally, we analyse to what extent potentials for trade between these two economic areas are important.

The use of panel data methodology in the empirical application cast some doubts on the usual interpretation of integration dummies when pooling time series or cross-section analysis is the methodology applied. A two steps estimation procedure is employed in order to exploit the richness of the data and to estimate time invariant parameters and dummy coefficients in a fixed effect model.

There are two novelties in our approach. First, to our knowledge this is the first attempt to investigate the role that infrastructure variables and per capita income differences play as explaining bilateral trade flows in a panel data framework. Only a few recent papers added infrastructure to the gravity equation but they used more limited methodologies. Limao and Venables (1999) used cross-section analysis over one year. Garman, Petersen and Gilliard (1998) also used cross-section analysis over various years. Finally, Bougheas et al. (1999) averaged the data over time and then applied seemingly unrelated regression analysis estimation. Squared differences in per capita income is the variable introduced to identify a possible Linder effect (Arnon, Spivak and Weinblatt, 1996). Since we are analysing a North-South integration process, this variable might be of significant importance. Real exchange rates were first introduced in the gravity model by Berstrand (1985, 1989). However, as Soloaga and Winters (1999) pointed out, the incorporation of price effects in a cross-section analysis does not give any information of whether a currency is over or under-valued. Only when the time dimension is included in the analysis, exchange rate movements become relevant. Soloaga and Winters (1999) also incorporated real exchange rate variables into the gravity equation. They averaged their variables over several three year periods and obtained Tobit estimates on single regressions.

The second novelty is the application of the gravity model to estimate trade flows between two economic blocks, EU and Mercosur, which are of special interest in world trade.

Section 2 presents a brief overview of Mercosur-EU trade relations. In Section 3 we review the literature on gravity models of international trade. In Section 4 the empirical analysis and results are shown. Section 5 evaluates the results and the prediction performance of our model. Finally, Section 6 concludes.

2. Regional integration: the Mercosur-EU FTA

The first regional movements in the 1950s and 1960s consisted on regional arrangements whose members were all either developed countries or developing countries. Two clear examples of North-North regional agreements were the European Community and the European Free Trade Area, whereas the Andean Pact or the Central American Common Market were both South-South arrangements. In the 1980s and 1990s a new movement towards regionalism started to flourish with the Canada-USA free trade agreement (FTA). This new regionalism can be characterised by a new feature: several agreements were signed between developed and developing countries. Mexico joined Canada and US to form the North American Free Trade Area (NAFTA) and the European Union (EU) signed several agreements with Central and East European countries. A very recent example of North-South integration is the EU-Mercosur trade agreement. The first negotiations started in 1995 with the signing of an Interregional Framework Agreement aimed to foster economic co-operation and closer trade relations between the two regional blocks. A further objective was the creation of a FTA in the year 2005. Until now, the exchanges developed in the agreement framework have consisted on gathering information and laying the grounds for future negotiations. Mercosur and EU had the third meeting of negotiations in Brasilia from the 7th to the 10th of November 2000. However, in practice concrete negotiations will only start in the year 2001, when questions relative to tariffs and services will be discussed as well.

On the side of the EU, incentives to engage in substantive negotiations with Mercosur will depend closely on the consolidation and progress recorded by the Mercosur as a customs union. On the side of Mercosur, trade, international bargaining and credibility considerations are incentives playing a major role to engage into FTA negotiations with the EU.

An unanswered question is whether this FTA is going to report benefits to all the members of both blocks. There have been several attempts to measure the effects of a Mercosur-EU FTA (Yeats, 1998; Diao and Somwaru, 2000). Most of them predict small net welfare gains for both partners.

Mercosur has surely a shorter history than the EU and therefore a more uncertain future. However, there is a shared consensus that since its inception Mercosur outperformed expectations. This is revealed in part by rapidly growing trade and investment flows. In fact, between 1991 and 1997 intra-Mercosur exports rose at a rate that trembled the growth of exports to the rest of the world. Nevertheless, if imports are taken as the indicator, the gap between the growth rates of intra and extra-regional trade flows is remarkably lower. This indicates no evidence of significant trade diversion.

Since its creation Mercosur has faced an extremely demanding agenda of extra-regional trade negotiations. It is considered as an emerging market offering good investment opportunities, with a population over two hundred millions of inhabitants (it represents half of the population of Latin America and Caribbean altogether) and an extension of almost 12 million squared kilometres. Mercosur has probably more to gain by joining the EU in a FTA rather than negotiating with North America, since Mercosur member countries already have free access to the North American market. An FTA with the EU will improve access to that market (Panagariya, 1996).

3. The Gravity Equation

Timbergen (1962) and Pöyhönen (1963) were the first authors applying the gravity equation to analyse international trade flows. Since then, the gravity model has become a popular instrument in empirical foreign trade analysis. The model has been successfully applied to flows of varying types such migration, foreign direct investment and more specifically to international trade flows. According to this model, exports from country *i* to country *j* are explained by their economic sizes (GDP or GNP), their populations, direct geographical distances and a set of dummies incorporating some kind of institutional characteristics common to specific flows.

Theoretical support of the research in this field was originally very poor, but since the second half of the 1970s several theoretical developments have appeared in support of the gravity model. Anderson (1979) made the first formal attempt to derive the gravity equation from a model that assumed product differentiation. Bergstrand (1985, 1989) has also explored the theoretical determination of bilateral trade in a series of papers, in which gravity equations were associated with simple monopolistic competition models. Helpman and Krugman (1985) used a differentiated product framework with increasing returns to scale to justify the gravity model. More recently Deardorff (1995) has proven that the gravity equation characterises many models and can be justified from standard trade theories. The differences in these theories help to explain the various specifications and some diversity in the results of the empirical applications.

There are a huge number of empirical applications in the literature of international trade which have contributed to the improvement of the performance of the gravity equation. Some of them are closer related to our work. First, in recent papers, Mátyás (1997) and (1998), Chen and Wall (1999), Breuss and Egger (1999), and Egger (2000) improved the econometric specification of the gravity equation. Second, Berstrand (1985), Helpman (1987), Wei, (1996), Soloaga and Winters (1999), Limao and Venables (1999) and Bougheas *et al*, (1999) among others, contributed to the refinement of the explanatory variables considered in the analysis and to the addition of new variables.

According to the generalised gravity model of trade, the volume of exports between pairs of countries, X_{ij}, is a function of their incomes (GDPs), their populations, their geographical distance and a set of dummies,

$$X_{ij} = b_0 \, Y_i^{b_1} Y_j^{b_2} N_i^{b_3} N_j^{b_4} D_{ij}^{b_5} A_{ij}^{b_6} \, u_{ij} \qquad (1)$$

where Y_i (Y_j) indicates the GDP of the exporter (importer), N_i (N_j) are populations of the exporter (importer), D_{ij} measures the distance between the two countries’ capitals (or economic centres) and A_{ij} represents any other factors aiding or preventing trade between pairs of countries. u_{ij} is the error term. An alternative formulation of equation (1) uses per capita income instead of population,

$$X_{ij} = \gamma_0 \, Y_i^{\gamma_1} Y_j^{\gamma_2} YH_i^{\gamma_3} YH_j^{\gamma_4} D_{ij}^{\gamma_5} A_{ij}^{\gamma_6} \, u_{ij} \qquad (2)$$

where YH_i (YH_j) are the exporter (importer) GDP per capita. The two models above are equivalent and the coefficients are expressed as: $\beta_3 = -\gamma_3$; $\beta_4 = -\gamma_4$; $\beta_1 = \gamma_1 + \gamma_3$; $\beta_2 = \gamma_2 + \gamma_4$. The second specification is usually chosen when the gravity model is applied to estimate bilateral exports for specific products, whereas the specification given by equation (1) is often used to estimate aggregated exports.

For estimation purposes, model (1) in log-linear form for a single year, is expressed as,

$$lX_{ij} = \beta_0 + \beta_1 lY_i + \beta_2 lY_j + \beta_3 lN_i + \beta_4 lN_j + \beta_5 lD_{ij} + \sum_h \delta_h P_{ijh} + u_{ij} \quad (3)$$

where *l* denotes variables in natural logs. P_{ijh} is a sum of preferential trade dummy variables. P_{ijh} takes the value one when a certain condition is satisfied (e.g. belonging to a trade bloc), zero otherwise. Our model includes dummy variables for trading partners sharing a common language and common border as well as trading blocs dummy variables evaluating the effects of preferential trading agreements. The coefficients of all these trade variables (δ_h) are expected to be positive.

A high level of income in the exporting country indicates a high level of production, which increases the availability of goods for exports. Therefore we expect β_1 to be positive. The coefficient of Y_j, β_2, is also expected to be positive since a high level of income in the importing country suggests higher imports. The coefficient estimate for population of the exporters, β_3, may be positive or negative signed, depending on whether the country exports less when it is big (absorption effect) or whether a big country exports more than a small country (economies of scale) . The coefficient of the importer population, β_4, has also an ambiguous sign, for similar reasons. The distance coefficient is expected to be negative since it is a proxy of all possible trade cost sources. Traditionally, the gravity model uses distance to model transport costs. However, recently Bougheas *et al* (1999) showed that transport costs are a function not only of distance but also of public infrastructure. They augmented the gravity model by introducing additional infrastructure variables (stock of public capital and length of motorway network). Their model predicts a positive relationship between the level of infrastructure and the volume of trade, which is supported using data from European countries. We took a further step in this direction by introducing a new infrastructure index (taking information on roads, paved roads, railroads and telephones) and differentiating between exporter and importer infrastructure as explanatory variables of bilateral trade flows. Our index is similar to Limao and Venables (1999) index. We also incorporated differences in incomes between exporters using a variable similar to that in Arnon, Spivak and Weinblatt (1996). Our variable $ydif_{ij}$ is constructed as the square of the difference in per capita incomes. Finally, a real exchange rate variable is added to our specification, once the time dimension is incorporated in the analysis, as shown in next section.

For a single period, the augmented gravity model is specified as follows,

$$lX_{ij} = b_0 + b_1 lY_i + b_2 lY_j + b_3 lN_i + b_4 lN_j + b_6 lD_{ij} + b_7 l\,I_i + b_8 l\,I_j + b_9 ydif_{ij} + \sum_h g_h P_{ijh} + u_{ij} \qquad (4)$$

where I_i, I_j denote respectively exporter and importer infrastructure.

4. Empirical evidence

In constructing our empirical model we consider a sample of 19 countries; 14 EU countries (Belgium and Luxembourg data are added together) and 5 Mercosur countries: the 4 formal members and Chile as associated country). The time period under study goes from 1988 to 1996. Our data consists therefore, of an unbalanced panel data of 342 trading pairs, with 3028 observations. Data sources are given in the appendix.

We estimated the gravity model of trade described in Section 3, in a panel data framework. The use of panel data methodology has several advantages over cross-section analysis. First, panels make possible to capture the relevant relationships among variables over time. Second, a major advantage of using panel data is the ability to monitor the possible unobservable trading-partner-pairs individual effects. When individual effects are omitted, OLS estimates will be biased if individual effects are correlated with the regressors.

The estimated gravity models with individual effects for each trading pair are given by,

$$lX_{ijt} = a_{ij} + b_1 lY_{it} + b_2 lY_{jt} + b_3 lN_{it} + b_4 lN_{jt} + b_5 lD_{ij} + \sum_h g_h P_{ijh} + u_{ijt} \qquad (5a)$$

$$lX_{ijt} = a_{ij} + b_1 lY_{it} + b_2 lY_{jt} + b_3 lN_{it} + b_4 lN_{jt} + b_5 lD_{ij} + b_6 lI_i + b_7 lI_j + \sum_h g_h P_{ijh} + u_{ijt} \qquad (5b)$$

$$\begin{aligned} lX_{ijt} &= a_{ij} + b_1 lY_{it} + b_2 lY_{jt} + b_3 lN_{it} + b_4 lN_{jt} + b_5 lD_{ij} + b_6 lI_i + b_7 lI_j + \\ &+ b_8 ydif_{ij} + b_9 lRER_{ij} + \sum_h g_h P_{ijh} + u_{ijt} \end{aligned} \qquad (5c)$$

where, α_{ij} stands for the individual effects, with (5a) corresponding to the basic gravity model and (5b, 5c) to the augmented gravity models. $lRER_{ij}$ denotes the natural log of country *i* real exchange rate defined as the local currency value of 1 unit of country *j* currency, multiplied by country *j* GDP deflator and divided by country's *i* GDP deflator, where *i* is the exporter country and *j* is the importer.

Since individual effects (α_{ij}) are included in the regressions, we have to decide whether they are treated as fixed or as random. From an a priori point of view, the random effects model (REM) would be more appropriate when estimating typical trade flows between a randomly drawn sample of trading partners from a larger population. On the other hand, FEM would be a better choice than REM when one is interested in estimating typical trade flows between an ex ante predetermined selection of nations (Egger, 2000). Since our sample includes trade flows among all the country members of the Mercosur and EU regional blocks, our intuition leads us to think that this view is consistent with a fixed effect specification. However, we also use the Hausman test to check whether the REM is more efficient that the FEM model. This will be the case under the null hypothesis of no correlation between the individual effects (α_{ij}) and the regressors.

A problem we faced with FEM is that we cannot directly estimate variables that do not change over time because the inherent transformation wipes out such variables. However, these variables can be easily estimated in a second step, running another regression with the individual effects as the dependent variable and distance and dummies as explanatory variables,

$$IE_{ij} = a_0 + a_1 D_{ij} + a_2 Adj + a_3 Lang + m_i \qquad (6)$$

where IE_{ij} denotes the individual effects, D_{ij} denotes distance, Adj is a dummy taking the value one when two countries share border and zero otherwise and Lang is a second dummy variable taking the value one when a pair of countries share the same language, zero otherwise.

We estimated equations (5a, 5b, 5c) for aggregate trade flows using several methodologies. Firstly, for comparison purposes, we used OLS ($\alpha_{ij}= \alpha$). The results are shown in Table 1. Secondly, we applied the regression to cross-section means (between estimation) obtaining similar results which are shown in Table 2. In both cases all the coefficients present the expected sign, apart from infrastructure variables, and their magnitude is similar to that found in other studies.

We performed an F-test to check for the poolability of the data. The restricted model is the pooled model given by equation (5), with the restrictive assumption of a single intercept ($\alpha_{ij}= \alpha$) and with the same parameters over time and across trading partners, as shown in Table 1. The unrestricted model, however, is the same behavioural equation but allows the intercept to vary across trading partners. Results from the test, reported in Table 1, show that we cannot accept the null hypothesis of equality of individual effects. This indicates that the OLS results are biased and we have to select a model with individual effects. The between estimates exploit the between dimension of the data (differences between individuals), but ignore any information within individuals. It is usually presented as an alternative to estimate long-run coefficients. As we can observe in Table 2, the coefficient estimates for the standard gravity model are very similar to those obtained by pooling the data (first column of Table 1). The same appears to be true looking at the augmented gravity model (second column of table 2). Nevertheless, we notice that the coefficients on exporter and importer infrastructure variables present the wrong sign, the former is not statistically significant but the latter is.

Tables 3 and 4 report respectively estimation results for the basic and augmented versions of the FEM an REM. The estimates of the country-pair individual effects are omitted for space considerations. In order to discriminate between the two models we test for the null hypothesis that the explanatory variables and the individual effects are uncorrelated using a Hausman test. The fixed effects estimates are consistent under both the null and alternative hypothesis whereas the random effects estimates are only consistent and efficient under the null hypothesis. Therefore REM will be preferred if the null hypothesis hold, otherwise FEM will be preferred.

Table 3 shows results for the test. The rejection of the null leads us to select fixed effects estimates since random effects estimates are inconsistent. Comparing our results of the pooled and fixed effects models, allowing for country-pair effects, as in FEM, slightly lowers the estimated income elasticities of trade, greatly rises the absolute value of population coefficients and more important, for the infrastructure variables, own infrastructure becomes statistically significant and has the correct sign, foreign infrastructure has still the wrong sign. The variable ydif (squared per capita income differential) presents a positive signed coefficient which is also significant. However, there might be a problem of multicollinearity. Another possible explanation for the positive sign is that the Heckscher-Ohlin effect (differences in factor endowments) dominates the Linder effect.

Finally, the integration dummy for EU countries increases in magnitude whereas the one for Mercosur membership decreases. Both present the expected positive sign.

A further refinement in our model consists in adding time dummies to the former explanatory variables. We might offer several interpretations for these time-specific parameters. They could be interpreted as a proxy for EU-Mercosur integration (globalisation), but they also could be showing the effects of business cycle phenomena. Since additional interpretations could be convincing, we would like to emphasise that these time-dummies will pick up the effects of any variables affecting bilateral exports that vary over time, are constant across trading-pairs and have not been included in the list of explanatory variables. Results are shown in the first column of Table 5. We conducted an Wald test to check for the significance of time effects. We could not accept the null of insignificant time dummies.

Since we suspect that cross-section heteroskedasticity may be present, given the importance of the cross-section dimension of our data (N=342), we estimate the same specification, but each pool equation is now downweighted by an estimate of the cross-section residual standard deviation. The second column of Table 5 reports the estimates of the two ways fixed effects model with cross-section weights. We obtain similar results, apart from the coefficient of the importer infrastructure variable, which is now positive signed, as the theory predicts, but non-significant.

In column 3 the income difference variable (ydif) is added to test for the existence of a Linder effect. Since we have problems of multicollinearity between the income variables and ydif, we estimated the model without exporter and importer income. The estimated coefficient on the variable ydif has now the expected negative sign and it is statistically significant. According to Linder’s trade model, bilateral trade will be greater when the per capita GDPs of the trading countries are more similar. The rest of explanatory variables present very similar estimated coefficients.

Column 4 of Table 5 reports our results when movements in the real exchange rate are considered. The estimated coefficient for real exchange rate is positive and significant, indicating that price competitiveness is important. A 10% depreciation (devaluation) of the exporter currency rises exports by 2.8% according to our estimations. Main results concerning the rest of explanatory variables remain unchanged.

The interpretation of the coefficients on the integration dummy variables is also relevant for our analysis. Since our model is estimated in natural logs, all dummy variables are given a value of one in natural logs when the correspondent condition is satisfied and a value of zero otherwise. Thus a value of 0.40 (the Mercosur dummy in column 1 of Table 5) indicates that intra-Mercosur trade is about 49% {=[exp(0.40)-1]*100} above what could be expected from the gravity model. Similarly, intra-UE trade is about {=[exp(0.17)-1]*100} 18% higher than expected levels.

An alternative specification to the FE model consists in estimating the gravity equation in first differences. This method has the advantage of eliminating the effects of possible autocorrelated disturbances, controlling at the same time for heterogeneity. Results[1] for the model in first differences and model 7 are very similar in order of magnitude and sign of the coefficients.

Finally, Table 6 reports the results obtained when the fixed effects from models 4, 5 y 7 are regressed on the distance variable and dummies which are fixed over time (common language and adjacency). According to our findings, only distance is statistically significant, whereas language and adjacency dummies present the correct sign but they are not significant. We obtain a very low R^2 coefficient, which means that there are other determinants of the trading-pair effects, different from the ones traditionally included in the analysis, which should be investigated. Our results are similar to those obtained by Chen and Wall (1999). The coefficient estimate for the distance variable is around 1 per cent, slightly higher than the one obtained in the pooled and between regressions (Tables 1 and 2) and very similar to the one obtained in the REM (Table 4).

5. Estimates of potential trade

We use the coefficients obtained from the gravity equations to forecast bilateral trade flows to calculate potential exports. Estimated coefficients from model 7 presented in Table 5 (Two ways fixed effects model with cross-section weights) served as the basis for the forecast[2]. Table 7 reports our estimates for potential exports of each of the Mercosur countries to the EU along with the actual export values for every year in our sample. The potential for Mercosur exports exceeds the actual export value in 1996 for each single country. For Chile, Argentina and Brazil, at the lower range, the difference between potential and actual exports to the EU represented respectively a 6%, 7% and 9% of actual exports, whereas for Paraguay and Uruguay these percentages amount 40% and 39% respectively. This means that the actual level of exports is below those that normal trade relations would support. However if we look at previous years, Uruguay and Paraguay results show a common picture, for these countries export potentials are higher than actual exports since 1994 and the difference has increases over time to a wide extent. The same seems to apply for Chile since 1992, apart from the results for 1995, where actual exports exceeded forecasted exports. As far as Argentina and Brazil are concerned, the evolution through time presents a mixed picture. Export potentials only exceeded actual exports in 1988-89, 1992-1993 and 1996. Explanations about increasing and decreasing potentials should be based on time specific factors, such as for example,climate phenomena affecting the agriculture sector.

[1] These results are not reported here (available upon requests).
[2] Very similar results were obtained with model 6.

We also forecasted intra-Mercosur trade flows in base on our estimates. Results are shown in Table 8. We observe that for all five countries (Mercosur current members plus Chile) export potentials seem to have been fully exploited before 1993. Total intra-Mercosur exports are bigger than our predictions since 1993 onwards.

6. Conclusions

The objective of this paper was to apply a gravity model to annual bilateral exports between 19 countries: Mercosur+Chile and the 15 current members of the EU. In doing so, we aim to analyse which are the determinants of Mercosur-European Union trade flows and to forecast trade potentials between the two blocs.

Our results show that exporter and importer incomes, as expected, have a positive influence in bilateral trade flows. Income elasticities are close to unity as predicted by the theory. Exporter population has a large and negative effect in exports showing a positive absorption effect, whereas importer population has a large and positive effect on exports, indicating that bigger countries import more than small countries.

We investigated the role that infrastructure variables, income differences and exchange rates play as explaining bilateral trade flows in a panel data framework. This framework, which allowed for trading-pair heterogeneity, was shown to be statistically superior to the standard model. Our findings support the hypothesis of the importance of these variables since they are all statistically significant and present the expected sign, apart from the importer infrastructure variable which is not significant. Our results concerning infrastructure might have some important implications for economic policy. Viewing infrastructure as a international public good rises the question of how the cost of infrastructure should be shared between trading partners. For Mercosur-EU trade it seems that only exporter infrastructure fosters trade, therefore investing to improve the trading-partner infrastructure appears not to have spill-over benefits for the investor.

When testing intra-bloc trade effects, both preferential dummy variables present a positive sign and are statistically significant, suggesting that belonging to one of the two preferential arrangements fosters trade. However, since in our study we are not considering the difference between trade creation and trade diversion (Endoh, 2000), these results have to be taken with caution.

With reference to potential trade estimates, our results show that the potential for Mercosur exports exceeds the actual export value in 1996 for each single country, but in previous years we observed a mixed picture. This could be interpreted as a positive starting point for the future trade liberalisation arrangements between both blocs on the side of Mercosur. Further research is needed to confirm this interpretation.

Table 1. OLS results for the basic and augmented generalised gravity equation

Right hand Side Variables	**Standard Gravity model**	**Augmented gravity model 1**	**Augmented gravity model 2**
Constant	0.2954(0.53)	0.7128(1.32)^{h}	-2.85 (-3.27)^{h}
Exporter Income	1.301(24.54)^{h}	1.282(23.91)^{h}	1.23 (23.65)^{h}
Importer Income	1.197(24.18)^{h}	1.388(26.65)^{h}	1.26 (21.33)^{h}
Exporter Population	-0.407(-7.91)^{h}	-0.384(-7.78)^{h}	-0.33 (-7.13)^{h}
Importer Population	-0.245(-4.42)^{h}	-0.352(-6.47)^{h}	-0.23 (-3.65)^{h}
Distance	-0.906(-38.20)^{h}	-0.925(-39.50)^{h}	-0.85 (-32.46)^{h}
Exporter Infrastructure	-	-0.003(-0.40)	-0.0005 (-0.06)
Importer Infrastructure	-	-0.08(-8.59)^{h}	-0.08 (-8.94)^{h}
Per capita income differential	-	-	-0.23 (-5.28)^{h}
Real exchange rate	-	-	0.54 (4.60)^{h}
EU dummy	0.11(1.94)^{m}	0.10 (1.73)^{m}	0.12 (2.13)^{m}
Mercosur dummy	0.65 (4.29)^{h}	0.48 (2.90)^{h}	0.41 (3.10)^{h}
Adjusted R^2	0.830	0.834	0.837
F (341, 2676/2678/2680)	58.36	57.77	56.62
SSR	3508.5	3431	3358
Number of observations	3028	3028	3028

Notes:

All variables except dummies are expressed innatural logarithms.

Estimation uses White's heteroskedasticity-consistent covariance matrix estimator.

t-statistics are in parentheses.

^{h} *denotes significance at the 1% level,* ^{m} *denotes significance at the 5% level and l denotes significance at the 10% level.*
F(n-1,nT-n-K) degrees of freedom in brackets. Where K is the number of variables in the regression, n is the number of trading pairs and T is the number of time periods. The number of observations equals (n x T).

Table 2. Between (OLS on means)* results for the *basic and augmented generalised gravity equation

Right-Hand-Side Variables	Standard Gravity model	Augmented gravity model 1	Augmented gravity model 2
Exporter Income	1.31 (11.21)	1.32(9.87)[h]	1.31 (8.58)[h]
Importer Income	1.21(10.37) [h]	1.42 (10.59)[m]	1.39 (9.88)[h]
Exporter Population	-0.39(-3.43)[h]	-0.37 (-3.14)[m]	-0.40 (-2.69)[h]
Importer Population	-0.24(-2.12)[h]	-0.34 (-2.90)	-0.35 (-2.68)[h]
Distance	-0.93 (-16.07)[h]	-0.94(-16.40)[h]	-0.89 (-14.20)[h]
Exporter Infrastructure	-	-0.015(-0.57)	-0.017 (-0.64)
Importer Infrastructure	-	-0.083(-3.11)[h]	-0.08 (-3.23)[h]
Per capita income differential	-	-	-0.19 (-1.93)[m]
Real exchange rate	-	-	0.17 (0.65)
Adjusted R^2	0.844	0.85	0.852
SSR	351.80	341.70	336
Number of observations	342	342	342

Notes: See Table 1

Table 3. Regression results for the Fixed Effect model

Right hand Side Variables	Standard Gravity model	Augmented gravity model 1	Augmented gravity model 2
Exporter Income	0.773 (6.11)[h]	0.82 (6.63)[h]	1.18 (9.95)[h]
Importer Income	1.19 (9.98) [h]	1.16 (9.69)[h]	1.05 (7.55)[h]
Exporter Population	-7.24 (-7.54)[h]	-7.47 (-7.85)[h]	-8.01 (-8.21)[h]
Importer Population	5.57 (9.30)[h]	5.73 (9.69)[h]	4.67 (8.17)[h]
Distance	-	-	-
Exporter Infrastructure	-	0.11 (3.98)[h]	0.10 (3.79)[h]
Importer Infrastructure	-	-0.07 (-3.28)[h]	-0.08 (-3.56)[h]
Per capita income differential	-	-	0.34 (3.58)[h]
Real exchange rate	-	-	0.39 (6.38)[h]
EU dummy	0.07(5.95)[h]	0.16(5.97)[h]	0.15 (5.88)[h]
Mercosur dummy	0.16(4.73)[h]	0.38 (4.91)[h]	0.38 (4.90)[h]
Adjusted R^2	0.97	0.977	0.978
SSR	416.23	410.73	400.82
Hausman Test (χ^2, degrees of freedom in brackets)	89.14 (6 d.f.)	409.15 (8 d.f.)	679.05 (10 d.f.)
Number of observations	3028	3028	3028

Notes: See Table 1

Table 4. Regression results for the Random Effects model (Generalised Least Squares Estimation)

Right hand Side Variables	Standard Gravity model 1	Augmented gravity model 2	Augmented gravity model 3
Constant	-1.53 (-1.11)	-1.53 (-1.11)	-4.34 (-3.08)[h]
Exporter Income	0.98 (13.13) [h]	0.89 (11.44)[h]	1.062 (13.49)[h]
Importer Income	0.84 (11.24)[h]	0.94 (12.07)[h]	0.77 (9.77)[h]
Exporter Population	-0.17 (-1.84)[m]	-0.15 (-1.56)	-0.31 (-3.19)[h]
Importer Population	0.17 (1.78)[m]	0.13 (1.41)[h]	0.29 (3.06)[h]
Distance	-1.01 (-19.48)[h]	-1.00 (-18.81)[h]	-1.01 (-17.64)[h]
Exporter Infrastructure	-	0.03 (3.48)[h]	0.054 (3.04)[h]
Importer Infrastructure	-	-0.02 (-2.93)[h]	-0.045 (-2.59)[h]
Per capita income differential	-	-	0.017 (0.30)
Real exchange rate	-	-	0.61 (10.41)[h]
EU dummy	0.16 (3.85)[h]	0.16 (3.89)[h]	0.16 (3.91)[h]
Mercosur dummy	0.30 (3.93)[h]	0.305 (3.96)[h]	0.30 (3.97)[h]
Adjusted R^2	0.976	0.976	0.977
SSR	488.01	484.26	465.07
Number of observations	3028	3028	3028

Notes: See Table 1

Table 5. Regression results for the two ways Fixed Effects model

Right hand Side Variables	Model 4: No Weights	Model 5: Cross-section Weights	Model 6: Gravity model with Linder effect	Model 7: Gravity model with Real Exchange. Rate
Exporter Income	0.87 (6.11) ^{h}	0.69 (28.94)^{h}	-	0.917 (35.51)^{h}
Importer Income	1.21 (7.35)^{h}	1.09 (43.30)^{h}	-	0.97 (41.88)^{h}
Exporter Population	-7.56 (-7.93)^{h}	-5.92 (-34.86)^{h}	-5.23 (-32.76)^{h}	-5.62 (-32.15)^{h}
Importer Population	5.65 (9.82)^{h}	4.08 (25.53)^{h}	4.24 (29.97)^{h}	3.98 (25.98)^{h}
Exporter Infrastructure	0.12 (4.47)^{h}	0.07 (12.38)^{h}	0.07 (15.99)^{h}	0.07 (13.49)^{h}
Importer Infrastructure	-0.06 (-2.55)	0.001 (0.23)	-0.0025 (-0.56)	-0.008 (-1.97)
Per capita income differential	-	-	-0.096 (-26.19)^{h}	-
Real Exchange Rate	-	-	0.26 (24.41)^{h}	0.28 (28.32)^{h}
EU dummy	0.17 (5.31)^{h}	0.06 (18.79)^{h}	0.043 (10.68)^{h}	0.073 (19.15)^{h}
Mercosur dummy	0.39 (4.88)^{h}	0.39 (14.40)^{h}	0.41 (14.22)^{h}	0.33 (11.99)^{h}
Dummy 1989	0.17 (0.67)	0.04 (14.07)^{h}	0.09 (28.45)^{h}	0.04 (12.14)^{h}
Dummy 1990	0.39 (4.38)^{h}	0.16 (41.48)^{h}	0.31 (87.44)^{h}	0.16 (37.82)^{h}
Dummy 1991	0.02 (4.04)^{h}	0.12 (26.57)^{h}	0.31 (76.78)^{h}	0.11 (22.82)^{h}
Dummy 1992	0.14 (1.89)^{m}	0.10 (16.40)^{h}	0.38 (77.69)^{h}	0.08 (13.15)^{h}
Dummy 1993	-0.011 (-0.23)	-0.015 (-2.13)^{m}	0.30 (51.56)^{h}	-0.04 (-5.17)^{h}
Dummy 1994	0.03 (0.66)	0.035 (4.01)^{h}	0.43 (67.11)^{h}	0.006 (0.65)
Dummy 1995	0.07 (1.02)	0.12 (11.79)^{h}	0.63 (88.28)^{h}	0.09 (8.43)^{h}
Dummy 1996	-0.015 (-0.19)	0.08 (7.44)^{h}	0.64 (83.62)^{h}	0.05 (3.98)^{h}
Wald test (H_0=no time dummies)	χ^2=64.11^{h}	χ^2=6769.32^{h}	χ^2=6769.32^{h}	χ^2=6769.32^{h}
Adjusted R^2	0.98	0.99	0.99	0.99
SSR	401.37	411.04	416.87	403.83
Number of observations	3028	3028	3028	3028

Notes: See Table 1.

Table 6. Cross-section regression results. Individual effects regressed over distance and dummies.

Right hand Side Variables	*FE from model 4*	*FE from model 5*	*FE from model 7*
Constant	26.04 (6.23)[h]	28.04 (8.67)[h]	22.23 (7.29)[h]
Distance	-1.035 (-1.98)[m]	-1.03 (-2.59) [h]	-0.96 (-2.53)[h]
Language dummy	1.21 (0.45)	0.80 (0.38)	0.86 (0.44)
Adjacency dummy	0.027 (0.01)	0.58 (0.33)	0.61 (0.38)
Adjusted R^2	0.011	0.02	0.02
SSR	42271	25840	22255
Number of observations	342	342	342

Notes: see table 1.

Table 7. Mercosur potential exports to the EU

Estimates from gravity equation augmented with Linder effect and real exchange rate

Forecasted exports:	X_AR_EU	X_BR_EU	X_CH_UE	X_P_UE	X_UR_UE	X_MERC_EU
1988	3772866.46	12884103.6	2614865.21	320879.926	428688.903	20021404.1
1989	4021196.52	12060940.2	2811569.38	357014.349	451759.65	19702480.1
1990	4139056.52	14095230.7	3385707.88	396598.948	549219.617	22565813.7
1991	3992202.59	10166112.4	3269409.07	320363.204	534758.685	18282845.9
1992	4345984.01	13221531.1	3556978.74	321460.596	542639.176	21988593.6
1993	3900643.32	11162124.1	3150350.78	268192.618	472844.957	18954155.8
1994	4380545.68	11792374.5	3328236.05	250644.616	540665.952	20292466.8
1995	4758004.42	12984400.7	3982953.94	268188.503	600341.238	22593888.8
1996	4624665.99	12783037.8	3980906.96	231025.591	648256.686	22267893.1
Actual	X_AR_EU	X_BR_EU	X_CH_UE	X_P_UE	X_UR_UE	X_MERC_EU
1988	3244500.3	11145938.7	2801855.6	438288.3	1082276.2	18712859.1
1989	3144120.9	11554837.8	3177053.2	477420.6	756557.9	19109990.4
1990	4635290.1	12366847.4	3513363.8	582842.2	762010.6	21860354.1
1991	4833764.1	12157344.3	3407920.9	375953.3	491519.9	21266502.5
1992	4443373.7	12482869.7	3516853.6	256740.5	497936.9	21197774.4
1993	3866548	11063763.7	2814178.9	288461.8	428194.2	18461146.6
1994	4580746.4	13449477.6	3173118.5	242499.8	466863.8	21912706.1
1995	5021491.3	14168870.7	4238894.7	242500.4	476106.5	24147863.6
1996	4309775	11731336.2	3742086.2	164789.9	467046.9	20415034.2
Difference	X_AR_EU	X_BR_EU	X_CH_UE	X_P_UE	X_UR_UE	X_MERC_EU
1988	528366.163	1738164.92	-186990.386	-117408.374	-653587.297	1308545.03
1989	877075.616	506102.425	-365483.822	-120406.251	-304798.25	592489.719
1990	-496233.581	1728383.34	-127655.919	-186243.252	-212790.983	705459.603
1991	-841561.508	-1991231.95	-138511.829	-55590.0963	43238.7853	-2983656.6
1992	-97389.6911	738661.365	40125.1442	64720.0963	44702.2765	790819.191
1993	34095.3181	98360.4172	336171.876	-20269.182	44650.7574	493009.187
1994	-200200.721	-1657103.09	155117.549	8144.81584	73802.1524	-1620239.29
1995	-263486.884	-1184469.96	-255940.758	25688.1025	124234.738	-1553974.76
1996	314890.992	1051701.64	238820.765	66235.691	181209.786	1852858.87
% Change	X_AR_EU	X_BR_EU	X_CH_UE	X_P_UE	X_UR_UE	X_MERC_EU
1988	16%	16%	-7%	-27%	-60%	7%
1989	28%	4%	-12%	-25%	-40%	3%
1990	-11%	14%	-4%	-32%	-28%	3%
1991	-17%	-16%	-4%	-15%	9%	-14%
1992	-2%	6%	1%	25%	9%	4%
1993	1%	1%	12%	-7%	10%	3%
1994	-4%	-12%	5%	3%	16%	-7%
1995	-5%	-8%	-6%	11%	26%	-6%
1996	7%	9%	6%	40%	39%	9%

Notes:

X_AR_EU stands for exports from Argentina to the EU, X_BR_EU stands for exports from Brazil to the EU, X_CH_EU stands for exports from Chile to the EU, X_P_EU stands for exports from Paraguay to the EU X_UR_EU stands for exports from Uruguay to the EU and X_MER_ EU stands for exports from Mercosur plus Chile to the EU.

Table 8. Intra-Mercosur potential exports

Estimates from gravity equation augmented with Linder effect and real exchange rate

Forecasted exports:	X_AR_MERC	X_BR_MERC	X_CH_MERC	X_P_MERC	X_UR_MERC	X_INTRA_MERC
1988	2329339.98	3082267.36	582300.674	305947.898	409795.18	6709651.1
1989	2786503.44	2715159.3	642314.347	370453.842	461100.791	6975531.717
1990	2721727.67	3304729.91	774471.572	409099.366	564132.557	7774161.075
1991	2662404.3	2811782.86	785195.74	332620.996	568885.689	7160889.583
1992	3014255.49	4081917.65	890679.603	342261.741	597588.856	8926703.34
1993	3012119.56	3873043.38	873235.575	316700.945	575057.635	8650157.102
1994	3677318.44	4391065.7	1003239.56	323215.491	713583.46	10108422.65
1995	6107491.2	6947827.64	1736052.44	514955.728	1176161.32	16482488.33
1996	6588841.92	7332956.35	1894616.23	486225.427	1384449.36	17687089.28
Actual	X_AR_MERC	X_BR_MERC	X_CH_MERC	X_P_MERC	X_UR_MERC	X_INTRA_MERC
1988	1134600	2178000	560200	155100	347700	3844200
1989	1778700	2060000	542900	421900	542400	4823700
1990	2295000	1803900	656200	409400	611600	5146900
1991	2464800	2985900	795100	306900	579700	6364300
1992	2907800	5020600	983800	293800	594100	8851400
1993	4275800	6504900	1105100	329400	713700	11868100
1994	5801900	6919900	1362600	457600	941300	14173500
1995	8253500	7363300	1780200	559100	1032000	17264200
1996	9690000	8360200	1770600	684400	1194900	19987200
Difference	X_AR_MERC	X_BR_MERC	X_CH_MERC	X_P_MERC	X_UR_MERC	X_INTRA_MERC
1988	1194739.98	904267.365	553500.674	150847.898	62095.1798	2865451.1
1989	1007803.44	655159.3	621614.347	-51446.1581	-81299.2089	2151831.717
1990	426727.667	1500829.91	747471.572	-300.633635	-47467.4427	2627261.075
1991	197604.302	-174117.143	758195.74	25720.9958	-10814.311	796589.5834
1992	106455.489	-938682.349	855579.603	48461.741	3488.85638	75303.34025
1993	-1263680.44	-2631856.62	828935.575	-12699.0548	-138642.365	-3217942.898
1994	-2124581.56	-2528834.3	950439.56	-134384.509	-227716.54	-4065077.347
1995	-2146008.8	-415472.362	1679752.44	-44144.2722	144161.323	-781711.6664
1996	-3101158.08	-1027243.65	1836916.23	-198174.573	189549.358	-2300110.721
%change	X_AR_MERC	X_BR_MERC	X_CH_MERC	X_P_MERC	X_UR_MERC	X_INTRA_MERC
1988	105%	42%	4%	97%	18%	75%
1989	57%	32%	18%	-12%	-15%	45%
1990	19%	83%	18%	0%	-8%	51%
1991	8%	-6%	-1%	8%	-2%	13%
1992	4%	-19%	-9%	16%	1%	1%
1993	-30%	-40%	-21%	-4%	-19%	-27%
1994	-37%	-37%	-26%	-29%	-24%	-29%
1995	-26%	-6%	-2%	-8%	14%	-5%
1996	-32%	-12%	7%	-29%	16%	-12%

Notes:

X_AR_MERC stands for exports from Argentina to Mercosur, X_BR_MERC stands for exports from Brazil to Mercosur, X_CH_MERC stands for exports from Chile to Mercosur, X_P_MERC stands for exports from Paraguay to Mercosur X_UR_MERC stands for exports from Uruguay to Mercosur and X_INTRA_ MERC stands for Intra- Mercosur exports.

References

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

Arnon, A., Spivak, A. and Weinblatt, J. (1996), 'The potential for trade between Israel, the Palestinians and Jordan' *World Economy* 19, pp.113-134.

Bergstrand, J. H. (1985), 'The gravity equation in international trade: some microeconomic foundations and empirical evidence' *The Review of Economics and Statistics* 67, 474-481.

Bergstrand, J. H. (1989), 'The generalised gravity equation, monopolistic competition, and the factor-proportions theory in international trade' *The Review of Economics and Statistics* 67, 474-481.

Bougheas *et al.* (1999), 'Infrastructure, transport costs and trade' *Journal of International Economics* 47, 169-189.

Breuss, F. and Egger, P. (1999), 'How reliable are Estimations of East-West trade potentials based on cross-section gravity analyses?' *Empirica* 26 (2), 81-95.

Chen, I-H. and H. J. Wall (1999), 'Controlling for Heterogeneity in gravity models of trade' Federal Reserve Bank of St. Louis Working Paper 99-010A.

Deardorff, A. V. (1995), 'Determinants of bilateral trade: does gravity work in a neo-classic world? NBER Working Paper 5377.

Diao, X. and Somwaru, A., S. (2000) 'An Inquiry on General Equilibrium Effects of MERCOSUR: An Intertemporal World Model', *Journal of Policy Modelling* (22)5 557-588.

Egger, P. (2000), 'A note on the proper econometric specification of the gravity equation' *Economics Letters* 66, 25-31.

Endoh, M. (2000), 'The transition of post-war Asia-Pacific trade *relations' Journal of Asian Economics* 10 (4), 571-589.

Garman, G.; J. Petersen and D. Gilliard (1998), 'Economic integration in the Americas: 1975-1992' Journal of Applied Business Research, Laramine; Summer.

Helpman, E. (1987), 'Imperfect competition and international trade: evidence from fourteen industrial countries' *Journal of the Japanese and International Economies* 1 (1) 62-81.

Helpman, E. and Krugman, P. (1985), *Market Structure and Foreign Trade. Increasing Returns, Imperfect Competition, and the International Economy*, The MIT Press, Cambridge, MA/London.

Limao, N. and A. J. Venables, (1999), ‘Infrastructure, geographical disadvantage and transport costs’ Policy Research Working Paper 2257, World Bank.

Mátyás, L. (1997), 'Proper econometric specification of the gravity model' *The World Economy* 20 (3), 363-368.

Oguledo, V.I. and Macphee, C.R. (1994), ‘Gravity models: a reformulation and an application to discriminatory trade arrangements’ *Applied Economics* 26, 107-120.

Panagariya, A. (1996), ‘The free trade area of the Americas: Good for Latin America?’ *World Economy* 19, pp.485-515.

Poyhonen, P.(1963), 'A tentative model for the volume of trade between countries' *Weltwirtschaftliches Archiv* 90, 93-99.

Soloaga, I. and Winters, A. (1999) ‘Regionalism in the Nineties: What effects on trade?’ Development Economic Group of the World Bank, mimeo.

Timbergen, J. (1962), 'Shaping the world economy. Suggestions for an international economic policy', New York.

Wei, S.-J. (1996), 'Intra-national versus international trade: how stubborn are nations in global integration?' NBER, Working Paper 5531.

Yeats, A. (1998); ‘Does Mercosur’s trade performance raise concerns about the effects of regional trade arrangements?’ The Word Bank Economic Review 12 (1), 1-28.

Appendix

Data Sources

CEPAL, Statistical Year Book for Latin America and the Caribbean. Various years. United Nation Publication:

-Bilateral trade Mercosur + Chile

-Infrastructure Mercosur + Chile

OEA, America en Ciphers 1965, 1970:
-Bilateral trade Mercosur+Chile

WILKE, James, Statistical Abstract of Latin America, Vol. XVII University of California Los Angeles (1976):
-Bilateral trade Mercosur+Chile

BID, Intra-ALALC exports (grouped according to Standard International Trade Classification) Various years (1965-1969):
-Bilateral trade Mercosur+Chile

OCDE, International Trade by Commodities Statistics ITCS. CD ROM 1960-1996:
-Bilateral trade for MERC countries

World Bank, World Development Indicators CD ROM 2000:

-GDP

-GDP deflator.

-Total exports and imports

-Exchange rates against dollar

-Population

-Infrastructure for MERC countries

World Bank, World Data 1995 CD ROM:

-Germany data before 1990

World Bank, Railways Database, http://www.worldbank.org/html/fpd/transport/rail/rdb.htm:
-Railways data

FAO, Faostat Agriculture Data, http://apps.fao.org/page/collections:
-Population (forecast)

John Haveman's web site and http://www.indo.com/distance:
-Distance, expressed in kilometres, is the distance between capital cities.

Estimated data:

-Bilateral real exchange rate (base 1995)
-Exports deflator (base 1995)
-Exports in real terms (base 1995)
-Trade weight
-Germany data prior 1990
-MERCropean Union totals