E C O N O M I C S   B U L L E T I N

DOES HETEROGENEITY MATTER IN THE CONTEXT OF THE GRAVITY MODEL?

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Abstract

This paper argues that there is a differential behaviour between the richest and the poorest economies in the gravity model framework. Results show that geographical and cultural factors are more important for developing than for developed economies, and a good economic policy in developing countries is to invest in technological innovation and in transport infrastructure.

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1. Introduction

Traditionally, when estimating a gravity model of trade, it is implicitly assumed that the coefficients of all the explanatory variables are the same for all the trading patterns. Empirically, this requires imposing the pooling assumption.

In this paper we test the pooling assumption in a gravity model augmented with technological innovation and transport infrastructure variables for a 62-country sample. We also aim to evaluate the empirical effects of technological innovation, transport infrastructure, cultural and geographical factors on international trade.

We find that the magnitude and sign of the explanatory variables depend on certain characteristics of the trading partners. Thus, the sample is divided into two groups of countries according to their level of income.[1] We consider the richest countries in the sample as developed and the poorest countries as developing ones. The estimation results show important differences concerning the goodness of fit and the significance and magnitude of the variable coefficients.

The next Section presents data and the estimated equation. In Section 3 the main empirical results are presented. Finally, in Section 4 we outline our conclusions.

2. Data and estimated equation

In order to evaluate the empirical effects of technological innovation, transport infrastructure, cultural and geographical factors on international trade, we use a gravity model (Deardorff, 1995; Anderson and van Wincoop, 2003) augmented with technological variables and a transport infrastructure index. Integration dummies are added to analyse the impact of trade agreements on international trade. A number of dummies representing geographical and cultural characteristics are also added. The model is expressed in additive form using a logarithmic transformation. This model is built based on Helpman and Krugman (1996) and includes "hard" and "soft" investments in infrastructure. "Hard" investments are proxied by the level of transport infrastructure in a country and "soft" investments are measured as technological innovation achievements (see Martínez-Zarzoso and Márquez-Ramos, 2005). The estimated equation is:

$$\begin{aligned} \ln X_{ij} &= \alpha_0 + \alpha_1 \cdot \ln Y_i + \alpha_2 \cdot \ln Y_j + \alpha_3 \cdot \ln P_i + \alpha_4 \cdot \ln P_j + \alpha_5 \cdot Adj_{ij} + \alpha_6 \cdot Isl + \alpha_7 \cdot Land + \\ &+ \alpha_8 \cdot CACM + \alpha_9 \cdot CARIC + \alpha_{10} \cdot MERC + \alpha_{11} \cdot NAFTA + \alpha_{12} \cdot CAN + \alpha_{13} \cdot UE + \\ &+ \alpha_{14} \cdot \ln Dist_{ij} + \alpha_{15} \cdot Lang_{ij} + \alpha_{16} \cdot ArCo_i + \alpha_{17} \cdot ArCo_j + \alpha_{18} \cdot difArCo_{ij} + \alpha_{19} \cdot Inf_i + \alpha_{20} \cdot Inf_j + u_{ij} \end{aligned} \quad (1)$$

where *ln* denotes natural logarithms, X_{ij} denotes the value of exports from country *i* to *j*, Y_i and P_i are income and population in the exporter's market, Y_j and P_j are income and population in the destination market, Adj_{ij} is a dummy that takes a value of 1 when countries share the same border and zero otherwise, *Isl* takes a value of 1 when the exporter or the importer are islands, *Land* is a dummy for landlocked countries, CACM is a dummy that takes a value of 1 when both countries belong to the Central American Common Market, CARIC is a dummy that takes a value of 1 when both countries belong to the Caribbean Community, MERC is a dummy that takes a value of 1 when both countries belong to Mercosur, NAFTA takes a value of 1 when countries are members of the North American Free Trade Area, CAN is a dummy representing

[1] The division of countries into developed and developing countries is imposed to the data.

Andean Nations Community members and UE takes a value of 1 when countries are members of the European Union. $Dist_{ij}$ is the geographical great circle distance in kilometres between the capitals of country *i* and *j*. $Lang_{ij}$ is a dummy for countries sharing the same language, $ArCo_i$ and $ArCo_j$ are technological variables[2] measuring technological innovation in the exporter and the importer countries and $difArCo_{ij}$ is the technological distance between trading partners (Filippini and Molini, 2003). This indicator is based on the insight that two countries can be far away from each other not only geographically, but also from a technological perspective. Inf_i and Inf_j are infrastructure variables measuring the level of transport infrastructures in the exporter and the importer countries.[3] Finally, $\boldsymbol{u}_{ij}$ is independently and identically distributed among countries.

The model is estimated with data for 62 countries in 1999. First, we perform OLS estimation on the double log specification as given by equation (1) without taking into account the zero values. However, since almost 20% of the observations for bilateral trade flows are zeros, a Tobit model is estimated in order to take into account the missing trade.

Data on bilateral exports are obtained from Statistics Canada (2001), income and population variables are from the World Bank's World Development Indicators (2001). Information about geographical and cultural dummies is from the CIA (2003) and the data for ArCo are obtained from Archibugi and Coco (2002).

In order to understand whether there exists a differential behaviour concerning the determinants of trade flows for developed and developing countries, we estimate equation (1) by interacting the exogenous variables (except integration dummies) with a dummy (DP)[4] that takes the value of 1 when trading partners are richer than the simple average in our sample. DP takes the value zero when trading partners are poorer than the simple average in our sample. We use the Wald test in order to check whether both the exogenous variable and its interaction with the dummy representing developed countries present a different coefficient. We cannot accept the null hypothesis of equality of the coefficients in the two sub-samples (developed and developing countries). Table 1 shows our final results.

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[2] ArCo is an index that takes into account three dimensions: Creation of technology *(number of patents*, *number of scientific papers)*, diffusion of technology *(Internet penetration*, *telephone penetration*, *electricity consumption*) and development of human skills *(gross tertiary science and engineering enrolment*, *mean years of schooling*, *adult literacy rate).*

[3] Although several measures of infrastructure are possible, this paper focuses on overland transport and technological innovation variables. The inclusion of a variable of maritime transport costs would be desirable since geographical distance is not a good proxy for this variable (Márquez-Ramos et al, 2005). Transport infrastructure variables are calculated with data on kilometres of paved roads and kilometres of motorways per square kilometre, taking into account the quality of the roads. For the construction of the transport infrastructure index we have used data from CIA (2003).

[4] **Developed countries:** Belgium-Luxembourg**,** United States, Norway, Iceland, Switzerland, Canada, Ireland, Denmark, Austria, Japan, Australia, Netherlands, Germany, Finland, France, Sweden, Italy, United Kingdom, Hong Kong, Singapore, Cyprus, Israel, Spain, Portugal, Republic of Korea, Greece, Czech Republic, Argentina, Slovak Republic.

Developing countries: South Africa, Uruguay, Costa Rica, Chile, Poland, Mexico, Trinidad and Tobago, Croatia, Brazil, Turkey, Panama, Colombia, Dominican Republic, Bulgaria, Algeria, Peru, Syrian Arab Republic, Paraguay, El Salvador, China, Jamaica, Egypt, Honduras, Nicaragua, India, Ghana, Pakistan, Sudan, Senegal, Nepal, Kenya, Mozambique, Tanzania.

3. Empirical results

Model 1 shows the estimation results for equation (1). All the explanatory variables are significant and show the expected sign, except for UE dummy. However, the magnitude of the income coefficients is lower than expected. The adjacency coefficient has the expected positive sign, but it is not significant. The landlocked coefficient is negative as expected, indicating that countries without direct access to the sea trade 62% less. The island dummy is negative,[5] as expected. The language dummy coefficient is positive and indicates that countries sharing a language trade 129% more than those with a different language. The European Union dummy coefficient is negative signed and statistically significant. Although this result has been found by other authors (e.g. Cyrus, 2002), we believe that the reason may be the presence of heterogeneity in the sample or the existence of zero values. Technological distance *($difArCo_{ij}$)* is significant, indicating that countries tend to trade more when they are "closer" from a technological point of view. The model has a high explanatory power (R^2 = 78.8%).

Model 2 presents the results for low income and high income countries, with the inclusion of iteration dummies. The results from the Wald test show that the poolability assumption is indeed rejected for bilateral exports and that the estimated parameters are not identical across bilateral relationships.

The income variable is more relevant for developed countries. A 1% increase in own GDP increases exports from developed countries by 0.52% (0.04+0.48), and by only 0.04% when exports are from developing countries. Very similar coefficients are obtained for foreign GDP. Since the gravity equation is an accepted methodology to analyse the effects of economic integration on trade flows, a lower magnitude obtained in the elasticities of income may indicate that the costs and benefits of integration and globalisation could be unevenly distributed among the richest and the poorest countries and in favour of the former (see Garman et al., 1998).

The coefficients for population variables present positive signs, but of a very low magnitude for developed countries and a magnitude close to unity for developing countries. As developing countries are more specialised in labour intensive exports, the results indicate that greater availability of cheap labour force in developing countries fosters trade, whereas in developed the trend of population growth is stable and almost close to zero (see Filippini and Molini, 2003).

The magnitude of the distance coefficient is lower for developed, -0.72 (-0.97+0.25), than for developing countries (-0.97). The adjacency dummy coefficient falls 68%(-0.45/0.66) for developed countries and also the language dummy is reduced by 50% (-0.53/1.04) when countries are developed. Therefore, the responsiveness of trade to adjacency falls by about 36% {[exp(-0.45)-1]*100} and to language by 41% {[exp(-0.53)-1]*100}.

Summarising, results show that trade flows are more sensitive to geographical and cultural variables (adjacency, geographical distance and language) for developing than for developed economies. Since developing countries face higher transport costs, higher institutional and informal barriers, and more limited access to market information they tend to trade more with neighbouring countries. The result that language links have an impact on international trade has also been found by other authors, such as Guo (2004).

[5] There are some authors that find island effects being positive and significant for both, importer and exporter, whereas others find that the signs depend on the direction of trade, being positive when imports are modelled as the dependent variable and negative when exports are modelled as the dependent variable (see Soloaga and Winters, 2001).

This author shows that language influences on trade are more significant in China (a developing country) than in the U.S. (a developed country).

The estimated coefficients for technological innovation and infrastructure variables are always significant and higher in magnitude for developing countries. Hence, technological innovation and transport infrastructure investments seem a good policy for developing economies to foster international trade flows.

Finally, Model 3 reports the Tobit estimation of the gravity equation with the interactive terms included. The results show several distinctive features compared to those obtained in Model 2. Income variables for the exporter and the importer show a higher magnitude for developed countries (1.66 and 1.73 respectively) than in the OLS estimation. Population variables for developed countries now present negative coefficients (-0.97 and -1.12 respectively), indicating that an increase in population deters trade. This may be due to the richest countries in the sample exporting less when they are bigger (absorption effect) (see Martínez-Zarzoso and Nowak-Lehmann, 2003).

The adjacency dummy has a coefficient for developing countries that is more than double that in Model 2 and also the effect of some integration dummies is amplified (CACM, CARICOM and MERCOSUR). However, the NAFTA and CAN dummies are not significant and the EU dummy is now positive and significant. Geographical distance has a considerably lower effect on trade for developing countries and the coefficient for the interactive variable is positive but not significant, whereas language, technological innovation and transport infrastructure have a higher effect on trade flows, for both developed and developing countries, than in Model 2.

4. Conclusions

This paper shows that there are significant differences between developed and developing countries as far as the determinants of bilateral trade flows are concerned. A gravity equation augmented with technological innovation and transport infrastructure variables is estimated, using two alternative techniques and taking into account two different groups of countries classified according to their level of income.

The results obtained from the two estimation techniques indicate that the zero values should be taken into account, since the Tobit model shows important differences in the magnitude of the estimated coefficients with respect to OLS.

The results obtained for developed and developing countries indicate that trade flows are more sensitive to geographical and cultural variables (adjacency, geographical distance and language) for developing than for developed economies and the estimated coefficients for technological innovation and infrastructure variables are always significant and higher in magnitude for developing countries. Consequently, the volume of trade is not only governed by geographical aspects and a good economic policy in developing countries is to invest in technological innovation and in transport infrastructure. The effect of an improvement in these two aspects will significantly foster trade.

A further extension of the current research could be not to impose a priori the division of countries into developed and developing economies and to estimate both the number of "regimes" and their positioning.

Bibliography

Anderson, J. E. and van Wincoop, E. (2003), "Gravity with gravitas: A solution to the border puzzle", *American Economic Review* **93**, 170-192.

Archibugi, D. and Coco, A. (2002), "A new indicator of technological capabilities for developed and developing countries (ArCo)", Italian National Research Council.

Central Intelligence Agency –CIA–, (2003), *The World Factbook*. http://www.odci.gov/cia/publications/factbook

Cyrus, T. L. (2002), "Income in the gravity model of bilateral trade: Does Endogeneity Matter?", *The International Trade Journal* **XVI**, 2, 161-180.

Deardorff, A. V. (1995), "Determinants of bilateral trade: Does gravity work in a Neo-classical world", NBER Working Paper 5377.

Filippini, C. and Molini, V. (2003), "The determinants of East Asian trade flows: a gravity equation approach", *Journal of Asian Economics* **14**, 695-711.

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

Great circle distances between cities (2003): http://www.wcrl.ars.usda.gov/cec/java/lat-long.htm

Guo, R. (2004), "How culture influences foreign trade: evidence from the U.S. and China", *The Journal of Socio-Economics* **33**, 785-812.

Helpman, E. and Krugman, P. R. (1996), *Market Structure and Foreign Trade. Increasing Returns, Imperfect Competition, and the International Economy*, Cambridge, MA: MIT Press.

Márquez-Ramos, L., Martínez-Zarzoso, I., Pérez-García, E. and Wilmsmeier, G. (2005), "Determinants of maritime transport costs. Importance of connectivity measures". Mimeo.

Martínez-Zarzoso, I. and Márquez-Ramos, L. (2005), "International trade, technological innovation and income: A gravity model approach", WP-EC 2005-15 Working Paper, Instituto Valenciano de Investigaciones Económicas. http://www.ivie.es/

Martínez-Zarzoso, I. and Nowak-Lehmann, F. (2003), "Augmented Gravity Model: An empirical application to Mercosur-European Union trade flows", *Journal of Applied Economics* **VI**, 2, 291-316.

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

Statistics Canada (2001), *World Trade Analyzer*. http://www.statcan.ca/

World Bank (2001), *World Development Indicators*, Washington.

TABLE 1			
Variable	OLS (1)	OLS (2)	TOBIT (3)
Constant term	-19.36*** (-32.05)	-22.11*** (-28.97)	-48.36*** (-32.6)
Exporter's income	0.04*** (5.69)	0.04*** (5.01)	0.05** (2.3)
DP*Exporter's income	-	0.48*** (2.97)	1.61*** (3.29)
Importer's income	0.05*** (4.64)	0.04*** (3.74)	0.06*** (2.73)
DP*Importer's income	-	0.57*** (3.6)	1.67*** (3.5)
Exporter's population	0.98*** (55.1)	1.08*** (51.81)	1.64*** (36.1)
DP*Exporter's population	-	-0.76*** (-4.26)	-2.61*** (-5.1)
Importer's population	0.72*** (37.46)	0.78*** (35.43)	1.15*** (26.72)
DP*Importer's population	-	-0.66*** (-3.89)	-2.27*** (-4.59)
Adjacency dummy	0.24 (1.52)	0.66*** (3.12)	1.45*** (3.01)
DP*Adjacency dummy	-	-0.45* (-1.76)	-0.78 (-1.01)
Island dummy	-0.31*** (-3.72)	-0.38*** (-3.42)	0.12 (0.59)
DP*Island dummy	-	0.11 (0.79)	-0.71* (-1.84)
Landlocked dummy	-0.97*** (-12.92)	-0.85*** (-8.98)	-1.29*** (-7.12)
DP*Landlocked dummy	-	0.12 (0.99)	-2.22*** (-6.28)
CACM dummy	2.39*** (9.55)	2.24*** (7.72)	5.68*** (5.51)
CARICOM dummy	3.91*** (3.89)	3.92*** (3.87)	6.24*** (2.59)
MERCOSUR dummy	2.76*** (8.5)	2.16*** (5.55)	4.18*** (3.99)
NAFTA dummy	1.2 (1.51)	1.31*** (3.17)	1 (0.71)
CAN dummy	0.89* (1.87)	0.18 (0.38)	0.35 (0.14)
UE dummy	-0.26** (-2.45)	0.13 (1.56)	1.24*** (3.36)
Distance	-0.91*** (-24.13)	-0.97*** (-19.55)	-0.47*** (-5.17)
DP*Distance	-	0.25*** (3.69)	0.29 (1.57)
Language dummy	0.83*** (9.81)	1.04*** (10.63)	3.02*** (15.18)
DP*Language dummy	-	-0.53*** (-3.12)	-2.24*** (-5.11)
Exporter's ArCo	8.04*** (48.74)	9.77*** (38.05)	14.43*** (29)
DP*Exporter's ArCo	-	-5.67*** (-12.46)	-8.53*** (-6.19)
Importer's ArCo	5.68*** (32.69)	7.15*** (26.49)	9.97*** (20.15)
DP*Importer's Arco	-	-5.48*** (-12.12)	-6.25*** (-4.57)
Technological distance	-1.93*** (-11.61)	-3.09*** (-13.82)	-2.76*** (-6.09)
DP*Technological distance	-	1.91*** (4.58)	2.18 (1.64)
Exporter's infrastructure	0.88*** (24.89)	0.92*** (18.57)	1.38*** (11.27)
DP*Exporter's infrastructure	-	-0.24*** (-3.45)	-0.29 (-1.43)
Importer's infrastructure	0.71*** (16.94)	0.8*** (12.62)	1.27*** (10.72)
DP*Importer's infrastructure	-	-0.41*** (-4.86)	-0.47** (-2.33)
R-squared	0.789	0.808	-
Adjusted R-squared	0.788	0.806	-
S.E. of regression	1.499	1.437	-
Log likelihood	-	-	-8938
Scale Factor	-	-	3.37*** (75.25)
Number of observations	3126	3126	3782

Notes: ***, **, *, indicate significance at 1%, 5% and 10%, respectively. T-statistics are in brackets. The dependent variable is the natural logarithm of exports in value (current US$). Income, population and distance are also in natural logarithms. The estimation of Model 1 and 2 uses White's heteroscedasticity-consistent standard errors. DP is a dummy variable that takes the value one for developed countries, zero otherwise.