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A gravity border effect approach

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ACCESS TO OECD AGRICULTURAL MARKET:
A GRAVITY BORDER EFFECT APPROACH

Alessandro Olper and Valentina Raimondi[*]

Abstract

This paper uses the border effect estimate from a gravity model to assess the level of trade integration in agricultural markets between 22 OECD countries, over the 1995-2002 period. The empirical analysis shows that using a gravity equation derived from theory, in the estimation of the border effect, matters. A representative estimate of the border effect shows that crossing a national border into the OECD countries induces a trade-reduction effect by a factor of 8. This average value masks substantial differences in market access across the country groups considered, with higher value in trade between EU countries and lower in trade between CEEC countries. However, the trade integration between CEECs and others OECDs increases substantially in the observed period. Finally, the equivalent tariffs implied by the estimated border effects are not implausible when compared to the actual range of direct protection measures.

Keywords: agricultural trade, border effect, gravity equation, OECDs
JEL Classification: F13, F14, Q17

1. Introduction

The process of trade liberalization implied by WTO negotiations, as well as by unilateral initiatives such as Everything But Arms (EBA) of the European Union, has increased the demand for studies finalized towards an understanding of the 'real' tariff structure of countries. This paper contributes to this literature by analyzing the average market access in agriculture between OECD countries. We depart from recent literature on this subject in that we use an *indirect* estimation approach. Specifically, we estimate the (inverse) level of trade integration between the OECD countries using the gravity-border effect methodology.

The use of an *indirect* measure is due to the difficulties in estimating protection by *direct* measurements. Indeed, a look at the literature on the agricultural average protection of the EU reveals a spread of estimates, ranging from the 40% of Messerlin (2001) to the 10% of Gallezot (2003). While these differences can be explained by the data used, and the assumptions made in calculation (see Bureau and Salvatici, 2003), the evidence associated with direct protection measures remains

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questionable (Fontagné et al., 2005). First, average tariff figures mask a reality based on numerous tariff peaks. Secondly, it is quite difficult to include the complex system of preferential agreements, developed by many rich countries (notably the EU), in the estimation of average *ad valorem* tariffs. Moreover, zero tariffs and zero quotas do not necessarily mean free access due to measures at the border, such as sanitary, phytosanitary and technical regulations[1].

Given these problems, the literature now gives consideration to the possibility of using a complementary and indirect measure such as the border effect estimated from gravity equation. This approach, initiated by McCallum (1995) comparing intra-national trade between Canadian provinces to international trade between Canada and the U.S., has stimulated a subsequent large amount of research. The underlying idea is to measure the (inverse) level of integration between two countries, comparing their bilateral trade with respect to trade flows taking place within their own borders. The estimated *border effect* shows how much trade within countries is above international trade, due to cross-border measures such as tariffs, non-tariff barriers and all others factors that might impede trade.

Thus, the border effect captures *all* impediments to trade related to the existence of national borders. This could be a considerable advantage because most of those impediments are quite hard to measures directly. For instance, consider the lack of reliable statistics on technical, sanitary and phytosanitary barriers, so pervasive in agri-food markets, and the conceptual difficulty in estimating their trade (and welfare) effect. By using an overall picture based on an indirect estimation approach we overcome these problems.

Another advantage of using the border effect approach, recently stressed by Mayer and Zignago (2005), is that it accounts for the fact that most internal demand is met by domestic producers, not foreign. Thus an ideal protection index from the point of view of foreign firms needs a benchmark based on the best possible market access situation, that is the one faced by national producers on the home market. This is exactly what the estimated border effect tells us.

The McCallum (1995) estimate of border effect was extraordinarily high, indicating that Canadian cross provincial trade was on average 22 times – or 2200%! – larger than Canada-US cross-border trade in 1988. The underlying reason for this impressive number was explained only very recently by Anderson and van Wincoop (2003), showing that the McCallum finding, at least partially, was a combination of two key distortions: an *asymmetry effect* of the border on countries of different size, and a *miss-specification* of the traditional gravity equation with respect to what the gravity theory tells us.

In this paper we apply the theoretical gravity model developed by Anderson and van Wincoop (2003, 2004) to agricultural bilateral trade flows between 9 EU, 9 OECD and 4 CEEC countries, from 1995 through 2002. In the empirical analysis we try to answer two main questions. First, does a theory based gravity equation do a good job in the estimation of the border effect in the agricultural market? Second, is the border effect a plausible estimate of market access?

Our analysis is linked to the literature that used gravity-like models to analyze different features of agricultural trade costs. Recent examples in this direction deal with the effect of food safety standards on bilateral trade (see Otsuki and Wilson, 2001; Otsuki et al. 2001; Nardella and Boccaletti, 2003), the estimation of tariff equivalents of non-tariff barriers (Dihel and Walkenhorst, 2002), the impact of distance on US agricultural export (Wang et al. 2000), the effect of exchange rate uncertainty (Cho et al. 2002) and of tariff and non-tariff barriers on agricultural trade (Haveman and Thursby, 2002). However, till now, only a few studies (see, e.g., Furtan and Blain, 2004; Olper and Raimondi, 2004) have applied the border effect estimate to the agricultural market and, most importantly, none of these is based on a theoretical gravity model.

The paper is organized as follows. Section 2 summarizes the structure of the model and derives a theoretical gravity equation. Section 3 describes the data sources and variables used in the empirical model. Section 4 is devoted to the presentation of our empirical results. The final section discusses the main implications and our conclusions.

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[1] Another problem with traditional direct protection measurement such as simple, as well as weighted, average tariff, or coverage ratio of non-tariff barriers, comes from the sensitivity of those indexes to change in customs classification. For this reason the customs classification can be considered an important element in a country's trade policy (see Tavares, 2004).

2. The derivation of a theory-based gravity equation

2.1 Theoretical framework

Our main goal consists of the estimation of a bilateral trade model with a gravity specification derived from theory. Anderson and van Wincoop (2003) recently demonstrated that a proper derivation of the gravity equation from theory is crucially important to the validity of empirical results, and this is especially true in the case of border effect estimation (see Feenstra, 2002).

A gravity equation can be derived from a variety of different trade theories[2]. Specifically, Anderson and van Wincoop (2003, 2004) shown that trade models where the allocation of trade across countries can be analyzed *separately* from the allocation of production and consumption within countries $\{Y_i^k, E_i^k\}$, give a gravity-like structure.[3] These models yield gravity under two additional restriction: the utility function assumes a CES specification; the trade costs t_{ij}^k are proportional to the quantity of trade.[4]

Let X_{ij}^k the export from i to j in product class k. Anderson and van Wincoop (2004) show that the model yields the following compact characterization of trade pattern between exporter i and importer j

$$X_{ij}^k = \frac{E_j^k Y_i^k}{Y^k}\left(\frac{t_{ij}^k}{P_j^k \prod_i^k}\right)^{1-\sigma_k} \tag{1}$$

with

$$(\textstyle\prod_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} \frac{E_j^k}{Y^k} \tag{2}$$

$$(P_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\prod_i^k}\right)^{1-\sigma_k} \frac{Y_i^k}{Y^k} \tag{3}$$

where Y^k is world output in sector k, σ^k is the import elasticity of substitution among goods and, finally, $\prod_i^k$ and P_j^k are the so called 'multilateral resistance indices' that summarize the average trade resistance between a country and its trading partners.

As in the traditional gravity equation, trade depends positively on the size of each country and negatively on the trade barriers. However, the key implication of equation (1) is that bilateral trade depends on *relative* trade barriers, namely the bilateral barrier t_{ij}^k divided by the product of their 'multilateral resistance indices' $\prod_i^k$ and P_j^k. Thus, the gravity equation suggests that trade between two regions, after controlling for size, depends on the bilateral barrier between them, in relation to the average trade barriers that both regions face with all their trading partners. The interpretation is, as

[2] The first theoretical derivation of a gravity model is due to Anderson (1979). Deardorff (1998) derived gravity equations from the Hesckscher-Ohlin model, Bergstrand (1989) from models with monopolistic competition, while Eaton and Kortum (2002) from Riccardian models. On the theoretical derivation of the gravity equation, see the review of Feenstra (2004) and Anderson and van Wincoop (2004).

[3] A model is trade separable if the allocation of production and consumption for product class k $\{Y_i^k, E_i^k\}$ for each country i is separable from the bilateral allocation of trade across countries. This implies that the assumption about production function, technology, the degree of competition and the nature of preference, do not matter. This assumption is similar to the well noted separability assumption in final demand models (see Anderson and van Wincoop, 2004, for more details).

[4] This formulation is called 'iceberg' transport cost. It implies that the price p_{ij} charged by i for exports to j (inclusive of transport costs, on a c.i.f. basis), can be written as $p_i\ t_{ij}$ where p_i is the local supply price received by producers in country i net of any transport costs, on f.o.b. basis. Because $t_{ii} = 1$, and $t_{ij} \geq 1$ we have that t_{ij} units of the product must be shipped to country j in order for one unit to arrive. In other words the amount $(t_{ij} - 1)$ 'melts' along the way and is the *ad-valorem* tariff equivalent of trade costs.

Anderson and van Wincoop (2003) suggest, quite intuitive: 'the more resistant to trade with all others a region is, the more it is pushed to trade with a given bilateral partner'.[5]

Before deriving an estimable equation, there is the modeling of the unobservable trade cost function t_{ij}. Following other authors, we assume that the trade cost factor t_{ij} is a loglinear function of two key observable types of costs: (*i*) non-border cost proxy by bilateral distance d_{ij}, and (*ii*) whether there is an international border between *i* and *j*:

$$t_{ij} = d_{ij}^{\rho} b^{\delta_{ij}} \tag{4}$$

where *b* is one plus the tariff equivalent of all the trade barriers associated with the border, and δ_{ij} is equal to zero when two regions are located in the same country (intra-country-trade) and equal to 1 for cross-border or international trade.

Finally, it is very useful to separate the border costs *b* into those that generate rents and those which do not generate rents (see Evans, 2003, Anderson and van Wincoop, 2002). *Rent-border* costs are related to international trade policy such as tariffs and non-tariff barriers, and lead to rents for government and/or private beneficiaries. Such costs depend on the level of protection of the country *i*, and consist of an *ad valorem* tariff τ_{ij} and the *ad valorem* equivalent of non-tariff barriers ntb_{ij}

$$b_{rent} = (1+\tau_{ij})(1+ntb_{ij}) \tag{5}.$$

On the contrary, many border barriers result from factors unrelated to trade policy, and so do not generate rents. Such barriers are due to transaction costs generated by differences in language, culture, regulations, history, institutions and are, in most cases, more difficult to remove[6]. In empirical studies such *non-rent-border* costs are, for example, proxy by using linguistic ties, contiguity dummy variables or specific institutional proxy to capture information costs, the costs of writing any necessary contracts and the level of both formal and informal networks (see Evans, 2003).

The distinction between *rent* and *non-rent border* costs have significant and practical implications. Indeed, it is important to note that if much of the border effect arises from barriers that do not create rents - think for example to the coordination of safety regulations or the choice of currency – then, as suggested by Anderson and van Wincoop (2002), its welfare impact will be greater than a situation where much of the border effect is due to rent barriers, such as tariffs. However, the potential role for policy will be more complex because non-rent barriers are probably not so easily eliminated by policy choices. Thus, a preliminary and rough distinction between these two conceptually different components of the border effects should be important.

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[5] Another interesting aspect of the gravity structure is the invariance of trade patterns to domestic distribution costs. Thus, we can only identify *relative* trade costs with these classes of models. In other words, the estimate of trade costs keeps some region *i* and normalize $t_{ii} = 1$. This procedure treats the trade cost of *i* with itself as a purely local distribution cost, and divides all other trade costs by the local distribution cost in the region or country *i*.

[6] Another potential component of *non-rent border* costs are the so called consumer 'home bias' in preference. Indeed while the gravity theory assumes that preferences are the same for all agents, it is quite probable that consumers may be biased towards goods produced in their home countries. However, here we give little importance to 'home bias' in preference, because the large part of our products are not for final consumption. Previous evidence on the home bias in preference is, in any case, mixed. For example, Evans (2003) provides evidence suggesting that large border barriers are not a result of consumer home bias for OECD manufacturing industries. Instead, for papers that attribute a role for home bias in preference, in food international markets, see Lopez and Pagoulatus (2004) and Olper and Raimondi (2005).

2.2 Empirical specification

Moving the consumption and production terms from the right to the left of equation (1), to take into account of their potential endogenity, and replacing the trade costs factor with (4), yields the following logarithmic form of the theoretical gravity equation (where we omit for simplicity the the constant term):

$$\ln\left(\frac{X_{ij}}{E_j Y_i}\right) = (1-\sigma)\rho \ln d_{ij} + (1-\sigma)(\delta_{ij})\ln b - \ln(\prod_i)^{\sigma-1} - \ln(P_j)^{\sigma-1} \qquad (6).$$

In the estimation of this gravity equation the main problem is to take account of the unobservable multilateral resistance factors $\prod_i$ and P_j. To this end the literature proposes three main, but different, approaches (see Feenstra, 2002): the use of *price index* such as consumer price index (CPI) to measure the price effects in the gravity equation, as in Baier and Bergstrand (2001) and Fontagné et al. (2005); the use of non-linear least squares to solve the system of equations (1)-(3) as in Anderson and van Wincoop (2003); and, finally, the replacement of multilateral resistance terms with country dummies as in Hummels (2001) and Feenstra (2002).

As recently shown by the latter author, only the last two approaches lead to consistent estimates, however the former of these is more complex (and more efficient) so the use of the fixed effect method is preferable due to its simplicity, since the estimation can be performed with ordinary least squares. Another important advantage of using a fixed effects specification is to sweep out any other unobservable variables omitted in the trade cost function (4).

Thus we will run our key estimations using the fixed effects for source and destination countries. That is to say, introducing the border coefficient $\gamma = (1-\sigma)\ln b$, and the error term ε_{ij}, we obtain (once again dropping the constant term):

$$\ln\left(\frac{X_{ij}}{E_j Y_i}\right) = \rho(1-\sigma)\ln d_{ij} + \gamma(\delta_{ij}) + \beta_1^i \phi_i + \beta_2^j \phi_j + (1-\sigma)\varepsilon_{ij} \qquad (7)$$

where ϕ_i is an indicator variable that is unity if country *i* is the exporter, and zero otherwise, and ϕ_j another indicator variable that is unity if country *j* is the importer, and zero otherwise. Then the coefficients $\beta_1^i = \ln(\prod_i)^{\sigma-1}$ and $\beta_2^j = \ln(P_j)^{\sigma-1}$ will be an estimate of the multilateral indexes. In equation (7) the key parameters to be estimated, other than the fixed effects, are the distance coefficient $\rho(1-\sigma)$, and the border effect coefficient $\gamma = (1-\sigma)\ln b$[7]. Taking the antilog of the estimated border coefficients [$\exp(\gamma)$], we have an estimate of the so called border effect, namely how much intra-country trade is above international trade, after controlling for size, transport costs and any other unspecified trade cost.

Finally before concluding this section, it is interesting to compare equation (7) with a traditional gravity equation like (8)

$$\ln X_{ij} = \alpha_1 \ln Y_i + \alpha_2 \ln Y_j + \rho \ln d_{ij} + \gamma(\delta_{ij}) + \varepsilon_{ij} \qquad (8).$$

Clearly, the key difference between the a-theoretic specification (8) and equation (7) is that the former omits the multilateral resistance terms implied by the theory. Thus the estimate of the border coefficients would be biased because the trade costs t_{ij} are correlated with the multilateral resistance indices, which are themselves a function of trade barriers (see equations (1) to (3)).

[7] Note that the elasticity of substitution σ, because it is always in a multiplicative form with trade cost parameters, is not identified.

3. Data and measures

Our gravity model includes 22 OECD countries: 9 OECDs, 9 EUs and 4 CEECs (see Appendix 2). Let us consider the imports of the 22 OECD countries from all the other 22 OECD countries over the 1995-2002 period. The data set is almost perfectly 'square', presenting 3,872 (22 x 22 x 8) theoretical observations.[8] However, due to 52 (1,3%) zero bilateral trade flows, the real total observation used drops to 3,820.[9] Those trade data consider 40% of the world agricultural trade flow and 60% of the OECD (22) agricultural imports from the world. Summary figures for these bilateral trade flows are given in Appendix 1.

The needed data involve, primarily, bilateral trade, production and consumption data in a comparable industry classification. The trade data come from the United Nations Commodity Trade Data Base (COMTRADE). Here we consider the data reported by the importer countries using the Harmonised System (HS96) at 6-digit, and use the conversion table from HS96 to the International Standard Industrial Classification (ISIC) Rev.3 at 4-digits to aggregate import data values at the 2-digit level. Summary figures for this bilateral trade flow are given in Appendix 1.

This conversion allows the fully comparable classification of trade and agricultural production data. Indeed, the output data come from the OECD Structural Analysis (STAN) database that use ISIC Rev.3 at the 2-digit level. Our database considers the total agricultural trade and production data aggregated from the ISIC Rev.3 (code 01-05)[10]. The consumption data of the importer country are calculated as the differences between total agricultural production and total export to the world, plus total import from the world.

The empirical implementation of equation (7) needs intra-country trade data. However, these figures were not available for our country sample. Thus, as is common in the literature, a country's 'imports' from itself are calculated as in Wei (1996). Such imports are defined as the difference between total agricultural production and total export to the rest of the world. Both data come from the same sources described above.

Moreover, measures of distance between and within countries are needed. We used the intra-national distance estimate recently proposed by CEPII. This distance database has the considerable advantage of making internal distance constructions consistent with international distance calculations. Note that, as is evident from the specification of trade costs (4), and as shown empirically by Head and Mayer (2002), any overestimate of the internal distance relative to the external one will mechanically translate into an overestimate of the border effect. In the CEPII database the calculation is based on bilateral distances between cities, weighted by the share of the city in the overall population of the country. This procedure is used for both internal and international distances.

Finally, we take into account also whether or not two countries share a common border and a common language. Following Helliwell (1997), the two dummies take value 1 when country i and country j (for $i \neq j$) speak a common language and/or share a common border (0 otherwise). This will simplify the comparison of our basic specification with previous findings. However, note that in the fixed effect specifications, due to their time invariance, the impact of the language and contiguity dummies will be largely captured by the country's importer and exporter fixed effects.

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[8] Specifically we have 22 x 21 x 8 = 3,696 bilateral cross-border trade observations, plus 22 x 8 = 176 intra-country trade observations.

[9] As a general rule a country's observations are included only if there are at least five non-zero trade flows during 1995-2002. For this reason, the observations on Belgium, Luxembourg and Ireland are not considered, due to their large zero values. We also run regressions using the 52 zero trade flows, by expressing the dependent variable as $\ln(1+X_{ij})$, so that when $X_{ij} = 0$, $\ln(1+X_{ij}) = 0$. The results are qualitatively and quantitatively the same.

[10] Agriculture, hunting and forestry (01-02) and fishing (05).

4. Results

4.1 Base model vs. fixed effects

Table 1 reports the ordinary least squares (OLS) regressions of different specifications based on the gravity equation (7), pooled over the 1995-2002 period. In this case we estimated a single *average* border coefficient γ = (1- σ)ln b for all 22 OECDs, using a border dummy δ_{ij} equal to zero for intra-country trade, and equal to 1 for cross-border or international trade. For comparison purposes, we also report two traditional gravity specifications (base model) where the estimation does not account for the multilateral resistance factors implied by the theory.

Table 1. Average Border effect in agricultural trade between OECD countries

Model	Base Model		Fixed effects[a]	
Time period	1995-02	1995-02	1995-02	1995-02
	(1)	(2)	(3)	(4)
Ln E_j	1.10 (0.03)	1	0.65 (0.19)	1
Ln Y_i	1.18 (0.03)	1	-0.35 (0.20)	1
Ln Distance $_{ij}$	-1.11 (0.03)	-1.05 (0.03)	-1.46 (0.03)	-1.46 (0.03)
Language	1.39 (0.14)	1.47 (0.14)	0.11 (0.09)	0.11 (0.11)
Contiguity	0.40 (0.14)	0.55 (0.14)	0.32 (0.09)	0.32 (0.10)
Border coefficient (γ)	-3.45 (0.19)	-3.69 (0.18)	-2.10 (0.20)	-2.11 (0.16)
Average border effect (exp (- γ))	31	40	8	8
Adj R-square	0.644	0.536	0.842	0.793
# obs.	3820	3820	3820	3820

Notes: Each regression includes a common intercept. Dependent variable: lnX_{ij} in regressions (1) and (3); ln(X_{ij}/E_jY_i) in regressions (2) and (4). Robust standard errors are in parentheses (see text).
[a] Included fixed effect for source and destination countries.

The first column reports the results of estimating a McCallum type gravity equation that allows for non-unitary output and expenditure elasticity. The overall fit of this regression is in line with the usual findings in gravity literature, once again confirming the ability of the gravity equation to explain bilateral trade flows. All the estimated coefficients have the expected sign and are highly significant ($p < 0.01$). The importer and exporter consumption and production elasticity, equal to 1.10 and 1.18, respectively, are near to the unitary value predicted by the theory. The trade elasticity of distance, around –1.0, is also comparable with the usual findings, as well as the positive and significant coefficients of language and contiguity indicators. Two countries speaking the same language tend to trade 146% (= *exp* (1.39)-1) more with each other than otherwise, while two countries sharing a common border tend to trade 55% (= *exp* (0.40)-1) more than otherwise.

In this basic specification, the estimated border effect is quite large. A border coefficient of –3.45 means that intra-country trade is, on average, 31 (= *exp* (3.45)) times larger than the cross-border trade in OECD countries. An analogous estimate for agricultural trade in OECDs does not exist, however Furtan and Blain (2004), using a traditional gravity equation with a specification very close to column 1, found a border effect even stronger for Canada and US agricultural trade.

Because trade can affect consumption and production patterns, the specification in column (2) extends the basic gravity model by constraining the coefficients of these terms at unity. By doing so their potential endogeneity is accounted for. Controlling for endogeneity slightly increases the magnitude of the border coefficients, but induces a significant reduction in the overall fit of the regression, suggesting that endogeneity issues may be a problem.

In column (3) we include fixed effects for source and destination countries to check for unobserved multilateral resistance indices implied by the theory. Comparing columns (3) and (1) shows that this theoretical modification strongly reduces the estimated border coefficient. Now, crossing a national border inside the OECDs reduces trade by a factor of 8 (= *exp* (2.10)), a figure that better fits our intuition, and is within the same order of magnitude with the Anderson and van Wincoop (2003) findings for OECD countries.[11]

Overall, these results confirm that using a gravity equation derived from theory in the estimation of border effects matters. Indeed, an a-theoretic gravity equation strongly inflates the border effect estimate, that suffers an omitted variable bias, as discussed in section (2).[12]

Controlling for country specific effects also affects the other coefficients of the equation. Specifically, we can see a strong reduction in the language coefficients, an increase in the distance elasticity, and a switch in the sign of the exporter production elasticity that loses substantial significance. Note that with fixed effects included, the importer-consumption and exporter-production coefficients explain only the time dimension in bilateral trade. Indeed cross country (size) differences are now captured by country specific effects. Thus, the variation in bilateral trade during the observed period seems exclusively affected by demand pull, while supply push appears virtually nil.

Since bilateral trade barriers vary across countries, the average border effect shown above can mask substantial differences across country groups. For instance, zero tariff and zero non tariff barriers in the EU market should imply a significantly higher market access for intra-EU country than the average OECD level. In order to check for these differences, let us break down the 22 OECD sample into three ‘natural’ country groups: 9 EU, 9 OECD (non EU) and 4 CEEC countries. Thus, we are estimating six different border coefficients $\gamma_m = (1-\sigma)\ln b_m$, by means of six border dummy δ_{ij}, one for each of the following country group combinations: intra-EU, intra-OECD (non-EU) and intra-CEEC trade, and their bilateral combinations EU-OECD, EU-CEEC, and OECD-CEEC, respectively. In this case equation (7) will become:

$$\ln\left(\frac{X_{ij}}{E_j Y_i}\right) = \rho(1-\sigma)\ln d_{ij} + \gamma_1(EU_{ij}) + \gamma_2(OECD_{ij}) + \gamma_3(CEEC_{ij}) + \gamma_4(EUOECD_{ij}) + \gamma_5(EUCEEC_{ij}) + \gamma_6(OECDCEEC_{ij}) + \beta_1^i\phi_i + \beta_2^j\phi_j + (1-\sigma)\varepsilon_{ij} \quad (9).$$

The results are shown in table 2, comparing once again the differences between the base models vs. fixed effects. The estimated coefficients confirm our a-priori expectation, showing substantial differences in the degree of integration. For example, the intra-EU trade has, in all the specifications, a lower border coefficient, while the OECD-CEEC trade combination has the higher. However, stark inconsistency in the estimated border coefficients can be shown in the base model (columns 1 and 2). For example, the estimated border coefficients of intra-CEEC trade is close to (column 1) or lower than (column 2) the coefficients of EU-OECD trade and of EU-CEEC trade. These results are quite difficult to reconcile with a reality characterized by higher trade barriers in CEEC countries,

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[11] The authors found an average border effect for total trade between OECD countries of 5.2.

[12] Note that, this is especially true for unrelated countries, namely two countries that does not share a common language and a common border. Indeed, the border effect for related countries is less sensible to fixed effect specification. Thus, at least for OECD countries, language and contiguity dummies appear good proxies for multilateral trade indices.

associated to their preferential access into the EU market, and the historical higher level of integration between EU and OECD trade.

A very interesting question is now to understand what happens if we include country fixed effects suggested by the theory. This is shown in columns 3 and 4 of table 2. First, all the border coefficients but one (intra-CEEC) decrease substantially. Second, this reduction is particularly large for intra-OECD and EU-OECD trade, reconciling the inconsistency of the previous finding with common beliefs. These last results confirm and reinforce the importance of using a gravity equation derived from theory, because an a-theoretic gravity equation not only inflates the border effect estimate, but also produces inconsistency in the estimated level of integration between different trading partners.

Table 2. Border effects in the EU, OECD, and CEEC countries

Model	Base Model		Fixed effects[a]	
Time period	1995-02	1995-02	1995-02	1995-02
	(1)	(2)	(3)	(4)
Ln E_j	0.93	1	0.66	1
	(0.03)		(0.17)	
Ln Y_i	0.99	1	-0.37	1
	(0.03)		(0.18)	
Ln Distance $_{ij}$	-0.94	-1.00	-1.27	-1.27
	(0.04)	(0.37)	(0.04)	(0.04)
Language	1.14	1.13	0.02	0.02
	(0.14)	(0.14)	(0.10)	(0.10)
Contiguity	0.33	0.27	0.03	0.03
	(0.14)	(0.13)	(0.10)	(0.10)
Border coefficients				
EU	-2.92	-2.89	-1.61	-1.62
	(0.18)	(0.18)	(0.18)	(0.18)
OECD	-3.58	-3.54	-1.92	-1.92
	(0.23)	(0.23)	(0.22)	(0.22)
CEEC	-3.94	-3.77	-4.25	-4.25
	(0.26)	(0.25)	(0.26)	(0.26)
EU ◄► OECD	-3.87	-3.83	-2.18	-2.18
	(0.21)	(0.21)	(0.19)	(0.19)
EU ◄► CEEC	-4.51	-4.43	-3.91	-3.91
	(0.19)	(0.18)	(0.17)	(0.17)
OECD ◄► CEEC	-5.67	-5.57	-4.90	-4.89
	(0.22)	(0.22)	(0.20)	(0.21)
Adj R-square	0.696	0.609	0.867	0.825
# obs.	3820	3820	3820	3820

Notes: Each regression includes a common intercept. Dependent variable: ln X_{ij} in regressions (1) and (3); ln (X_{ij}/E_jY_i) in regressions (2) and (4). Robust standard errors are in parentheses (see text).
[a] Included fixed effect for source and destination countries.

In the fixed effects specification the level of agricultural trade integration among EU countries is the same order of magnitude as previous findings applied to total trade. For example, our results suggest that crossing a national border inside the EU reduces trade by a factor 5.1 (= *exp* (1.62)), a very close figure with the border effect of 4.3 found by Chen (2004) for total manufacture trade in 1996, using a fixed effects specification.

Not surprising, the level of EU integration between EU countries is unmatched in the other trade combinations considered here. With a border effect of 6.8, trade between OECD countries alone seems to have comparatively easier access than intra-EU trade, followed by a factor of 8.8 for EU-OECD trade. Finally, trade between OECD and CEECs, with a factor of 133, appears as the most impeded in our sample.

4.2 Time variation in border effects

As noted in section (2) gravity can only measure trade barriers relative to some benchmark. For instance, in our framework we compare trade barriers between countries to barriers within countries. However this can be problematic since different countries could have different barriers for internal trade (Anderson and van Wincoop, 2004). Moreover, the results could also be sensitive to the measurement of distance among and within countries, as shown by Head and Mayer (2002) and discussed in the previous section. However, all these issues do not affect the time variation in border effects, that are therefore informative of the evolution in market access.

Figures 1, 2a and 2b analyze the time evolution of the border effects over the observed period. Following Mayer and Zignago (2005), these figures are obtained through regressions identical to column (4) of Table (1) and (2), with added interaction terms between (each) border indicator δ_{ij} with year dummies. This procedure tends to smooth out the evolution of border effects compared to year-by-year estimates, which are more sensitive to outliers.

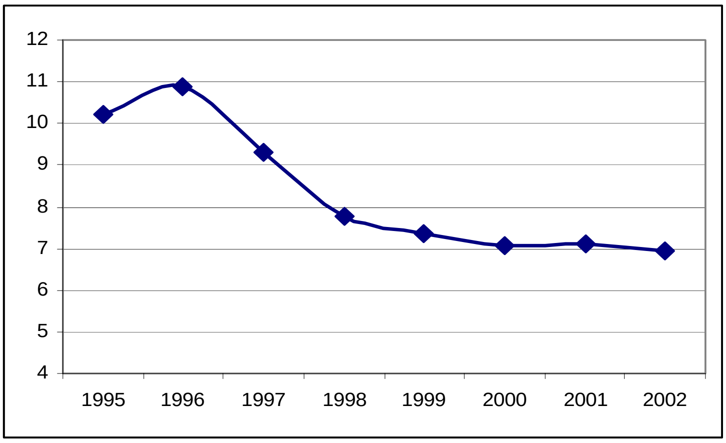

Figure 1. Border effect over time between OECD countries

Notes: The figure is based on the results of a regression identical to column (4) table 1, with added interaction between the border indicator and year dummies (see text).

At the aggregate level, the *average* OECD border effect decreases from a factor 10.2 in the 1995 to a factor 6.9 in 2002. However, this reduction in border effect is concentrated, especially in the 1996-2000 period, then the dynamics appear substantially flat. In general, it is quite difficult to draw strong conclusions from this pattern due to the short time period involved. However it appears that the increase in the average market access tends to coincide exactly with the implementation period of the Marrakech agreement.

Figure 2 breaks down the border effects of our country groups (Fig. 2a) and gives details for the EU, OECDs and EU-OECDs (Fig. 2b). Overall, the evolution in the border effects for each country combinations shows a generalized tendency to decrease. However the increase in the degree of integration changes substantially across different country groups, and is particularly strong in the trade combinations that involve CEEC countries as a partner. For instance, the border effect decreases from a factor 183 to a factor 93 for OECD-CEEC trade, and from a factor 66 to a factor 36 for EU-CEEC trade. This strong integration process is probably due to their recent WTO membership dates. This interpretation is reinforced by the fact that the intra-CEEC integration level does not change a lot in the observed period.

Analyzing the border effect evolution of intra-EU trade, our data suggest that the integration level increases substantially, passing from a factor of 6.3 in 1995 to a factor 3.9 in 2002. Note that from 1999 onward the beginning of the European Monetary Union (EMU) could explain the increase in intra-EU trade integration (see Baldwin, et al. 2005). Differently, the integration level between OECD non-EU countries remains more stable, moving from a factor of 7.5 to a factor of 6.9. Lastly, from figure 2b it appears quite clear that the intra-EU border effect follows a regular reduction. Instead, the increase in market access of OECDs with other OECD and EU countries shows a clear interruption after 2000, even appearing to decrease. Once again these results fit quite well with the interpretation based on the WTO agreement. Indeed, the 1994 GATT-WTO agreement could affect market access between OECDs but not, at least not directly, market access within EU countries.

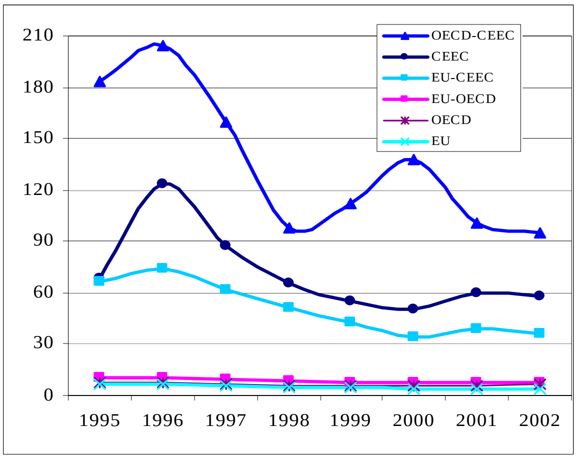

Fig. 2a

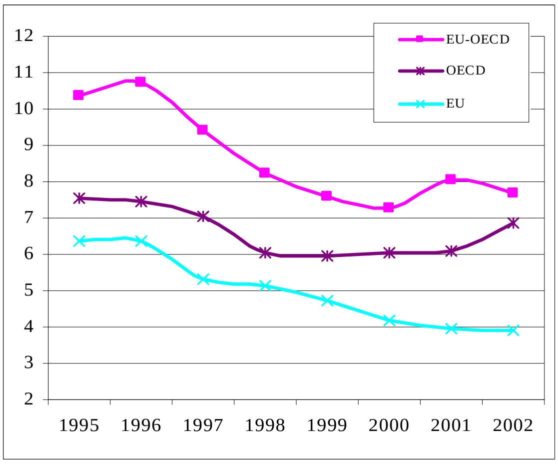

Fig. 2b

Figure 2. Border effects over time between OECD countries

Notes: The figures are based on the results of a regression identical to column (4) table 2, with added interaction between the border indicators and time dummies (see text).

4.3 Tariff equivalent of border barriers

Given the structural derivation of our gravity equation, in this section we will use the border coefficients discussed above to measure their implied *ad valorem* equivalent (AVEs). To this end, remember that from equation (7) of section 2.2, our estimated border coefficients are equal to $\gamma = (1-\sigma)\ln b$, where b is one plus the tariff equivalent of all the trade barriers associated with the presence of an international border and $\sigma > 1$ is the import substitution elasticity. Thus, the AVE associated with the border could be computed from the following relation: $AVE = \exp[\gamma/(1-\sigma)]-1$.

The main problem in converting the border coefficients to their respective AVEs is the choice of the import substitution elasticity. Indeed, there is no good guidance on the correct value of σ. Thus, as is commonly done in the literature, we estimated the AVE of border costs using three different elasticity values, spanning from 3 to 7 with a central (and preferred) value of 5.[13] The results from this exercise are reported in Table 3, borrowing the approach of Evans (2003).

The first two columns of Table 3 report the border effect averaged over 2000-2002, and representative 'bilateral' estimates of (*direct*) tariff rate, based on *Market Access Map* database (see footnote at the bottom of Table 3 for calculation details). The next columns report, for the three different elasticity values, the total implied AVEs of the border effects, and the corresponding unexplained AVE (= AVE – *tariff rate*), namely the portion of the AVEs not explained by tariff barriers. Let us focus the discussion on an intermediate value of elasticity of 5.
The all-inclusive AVEs of the border effects range from 40.9% for intra EU trade to 214% for OECD-CEEC trade. These values are somewhat higher than the results of previous studies based on OECD trade in manufactured goods, ranging from 45% to 116% (see Table 7 of Anderson and van Wincoop, 2004)[14]. Though these differences are in line with the higher level of protection that typically characterizes agricultural vs. manufactured goods in OECD countries, the implied AVEs of the border effects appear far higher than recognized tariff barriers, suggesting that transaction costs and non-distortionary border barriers are substantial. However this conclusion holds true especially for trade combinations involving the less developed CEECs, where the unexplained part of the AVE, for the same elasticity value, is always higher of 120%.

Table 3. Border effects, implied AVEs and bilateral tariff rates (%): average 2000-2002

			Import substitution elasticity and AVE (%)					
			Elasticity = 3		Elasticity = 5		Elasticity = 7	
Country group	Border effect average	Weighted bilateral tariff (%)	Total implied AVE	Unexpla-ined AVE	Total implied AVE	Unexpla-ined AVE	Total implied AVE	Unexpla-ined AVE
EU (intra)	3.9	-	98.5	98.5	40.9	40.9	25.7	25.7
OECD (non-EU)	6.5	19.1	154.8	135.7	59.6	40.5	36.6	17.5
EU-OECD	7.8	18.3	180.2	161.9	67.4	49.1	41.0	22.7
EU-CEEC	37.3	22.4	512.0	489.6	147.4	125.0	82.9	60.5
CEEC	58.6	27.1	666.7	639.6	176.9	149.8	97.2	70.1
OECD-CEEC	97.5	25.5	888.8	863.3	214.4	188.9	114.6	89.1

Notes: The first column reports the average 2000-2002 border effects estimated from a regression identical to specification 4 (Table, 2), with interaction term between each border dummy and year dummies. The second column reports average bilateral tariffs measured as follows. *Market Access Map* (www.CEPII.org) provide for 2001 country 'bilateral' weighted tariffs for all, but two countries (Korea and Norway) covered by our analysis. Starting from those figures we created a single tariff for each country group to reflect the average bilateral tariff protectionist of each combination, weighting each country (or group) average tariff by the respective shares of their exports in agricultural bilateral trade. Thus, for instance, if most trade flows from EU to the CEEC countries, then the average CEEC tariff receives a greater weight in the average bilateral tariff. The next columns report the total implied AVEs of border effects and the corresponding unexplained AVEs for three different elasticity values. (See text).

Differently, for trade involving OECD (non-EU) and EU-OECD countries the unexplained AVEs, ranging from 40.5% to 49.1%, appear more reasonable, especially if we recognize the important role played by non-tariff barriers to trade in agricultural markets. For example, Kee et al. (2004) recently showed that a theoretical consistent estimate of the *ad valorem* equivalent of NTBs for agricultural products is, on average, more than double the respective tariff component. The authors estimated an

[13] We start from the GTAP elasticity value for agricultural products, that typically range from 1.5 to 6. However, several recent papers have shown that GTAP elasticity is probably significantly low (see, e.g., Hummels, 2001; Head and Ries, 2001). For instance, this literature stressed that the estimated substitution elasticity tends to increase from around 4 to around 8, on passing from 1 to 3 digit industry, respectively. Thus, because we are working with an aggregate at 2 digit level and with homogeneous goods, a range of elasticity from 3 to 7 appears quite reasonable.
[14] Note, however, that these studies never include CEEC countries in the OECD sample.

AVE of agricultural NTBs equal to 32.6% for EU and 17% for the US, vis-à-vis an average tariff component of 12.7% and 3.5% respectively. Thus, in this light, our figures are not so implausible when compared to the actual range of direct protection measures.
Obviously, as is clear from Table 3, the results are sensitive to the substitution elasticity. Increasing (or decreasing) the substitution elasticity between home and foreign goods significantly decreases (increases) the estimated AVEs implied by border effects. As suggested by Yue et al. (2005), the intuition behind this is quite simple: the higher the elasticity, the smaller are the required domestic-foreign price gaps, induced by protection, to have consumers switch to domestic products.
Summing up, the exercise reported in this section suggests the following main considerations, conditional to the (unknown) *true* value of elasticity. First, the policy-unrelated component of border effect is important, especially in the presence of low elasticity values. Second, this component strongly decreases with the level of country development, showing that for intermediate and moderately high levels of elasticity the AVE implied by the border effects do not appear to be so far from the actual estimate of the (overall) market access restriction faced by rich countries.

5. Concluding remarks

In this paper we apply the theoretical gravity model developed by Anderson and van Wincoop (2003) to agricultural bilateral trade flows between 22 OECDs countries. The empirical analysis investigates the level of market access among different country 'bloc' combinations through the border effect approach, that is to say, through all the factors that contribute to a country's internal trade volume deviation from the gravity model prediction. The analysis strongly confirms that a proper derivation of the gravity equation from theory, matters in estimating border effects. In fact, an a-theoretic gravity equation not only inflates the border effect estimate, but also produces inconsistency in the estimated level of integration between different trading partners. Overall, these results are in line with the most recent empirical literature on gravity models.
A representative estimate of the average border effect in the OECD markets, after controlling for economic size, transport costs, and any other non specified trade costs, lies in the range of 10.2 to 6.9. This means that crossing a national border into the OECDs induces a trade-reduction effect of the same order of magnitude. However, this *average* border effect masks substantial differences across country groups. Not surprisingly, the level of integration between EU countries, with an average border effect of 5.1, is unmatched by other trade combinations. Instead, trade between OECD and CEECs, with a factor of 133, appears as the most impeded in our sample. Thus, given the magnitude of these border costs, an explanation of such costs could be a very important topic for further research.
In the observed period the level of market access showed a general tendency to decrease, and this was particularly strong especially for trade between the CEECs and both the EU and OECD (non-EU) countries. Interestingly, within the EU the data show a significant increase in the level of integration, part of which could be attributable to the European Monetaty Union that started in 1999.
Finally, given the structural derivation of our gravity equation, and a reasonable assumption of elasticity of substitution, we calculated the overall *ad valorem* tariffs implied by estimated border effects, and then compared them with actual measurements of direct tariff and NTBs. The overall picture that emerges from this exercise suggests that the components of border effects not related to trade policy are important, especially in the presence of low elasticity values. However, this component strongly decreases with the level of country development, showing that for intermediate and high elasticity values, the *ad valorem* tariff of border effects is not so far from the actual estimate of market access restriction faced by rich countries.

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Appendix 1 - Trade patterns

Table 1.A. EU total import and country groups market share

	EU total import (million US $)	***Import Originating from (%)***		
		EU	***OECD***	***CEEC***
1995	41,775	72.8	24.6	2.6
1996	42,607	73.7	24.0	2.3
1997	39,193	73.7	24.0	2.3
1998	39,186	75.3	22.4	2.3
1999	37,042	77.2	20.2	2.5
2000	33,308	75.0	22.4	2.5
2001	33,657	76.6	20.7	2.6
2002	36,068	77.8	19.3	2.8

Notes: Agricultural trade (ISIC cod. 01-05) of 9 EU countries with 9 (non-EU) OECD and 4 CEEC countries
Source: UN Comtrade database

Table 2.A. OECD (non-EU) total import and country groups market share

	OECD total imp. (million US $)	***Import Originating from (%)***		
		EU	***OECD***	***CEEC***
1995	33,867	11.3	88.4	0.4
1996	37,199	11.0	88.8	0.2
1997	34,210	10.9	88.8	0.2
1998	31,980	12.2	87.5	0.4
1999	31,836	12.7	87.0	0.4
2000	32,426	11.8	88.0	0.2
2001	32,470	11.5	88.3	0.2
2002	32,761	12.3	87.4	0.3

Notes: Agricultural trade (ISIC3 cod. 01-05) of 9 (non-EU) OECD countries with 9 EU and 4 CEEC countries
Source: UN Comtrade database

Table 3.A. CEEC total import and country groups market share

	CEEC total imp. (million US $)	***Import Originating from (%)***		
		EU	***OECD***	***CEEC***
1995	1,368	61.8	14.9	23.2
1996	1,858	68.9	19.4	11.7
1997	1,565	64.5	20.3	15.2
1998	1,621	64.4	17.6	17.9
1999	1,397	68.1	15.5	16.4
2000	1,470	69.6	13.9	16.4
2001	1,613	71.2	14.6	14.2
2002	1,694	71.4	13.8	14.9

Notes: Agricultural trade (ISIC3 cod. 01-05) of 4 CEEC countries with 9 EU and 9 (non-EU) OECD countries
Source: UN Comtrade database

Appendix 2 – The 22 OECD Trading countries in the model

OECD countries	Year of ratification
Australia	1971
Canada	1961
Japan	1964
Korea	1996
Mexico	1994
New Zealand	1973
Norway	1961
Switzerland	1961
United States of America	1961
EU countries	
Denmark	1961
France	1961
Germany	1961
Greece	1961
Italy	1962
Netherlands	1961
Portugal	1961
Spain	1961
United Kingdom	1961
CEECs countries	
Czech Republic	1995
Hungary	1996
Poland	1996
Slovak Republic	2000