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Intra-national versus international trade in the European Union: why do national borders matter?

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Abstract

The first objective of this paper is to estimate border effects among European Union countries. In this context, the specification of the gravity equation, together with the choice of the distance measure, are shown to be crucial for assessing the size of the border effect. The second objective is to evaluate the determinants of the cross-commodity variation in national border effects. Contrary to previous findings reported in the literature, we show that trade barriers do provide an explanation. In particular, technical barriers to trade, together with product-specific information costs, increase border effects, whereas non-tariff barriers are not significant. Our results further suggest that these barriers are not the only cause since the spatial clustering of firms is also found to matter.

Keywords: Border effects; Trade; EU countries; Industries; Gravity equation

JEL classification: F14; F15

1. Introduction

A growing literature has documented the negative impact of national borders on the volume of trade. This strand of research was initiated by McCallum (1995) who, using Canadian provinces and US states-level data in 1988, shows that trade flows between two

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Canadian provinces were about 22 times as large as their trade with US states, after controlling for a number of explanatory factors. Subsequent studies[1] have illustrated that domestic trade volumes usually tend to be five to twenty times larger than international trade volumes. While it is not surprising that national borders create a barrier to the free flow of goods, it is the *size* of the effect that is puzzling.

Recent research on the topic has moved from the simple exploration of border effects to the examination of their likely causes. First and foremost, national trade barriers (tariffs, quotas, exchange rate variability, transaction costs, different standards and customs, regulatory differences, etc.) appear as obvious candidates in causing the volume of domestic trade to exceed that of international trade since they increase the transaction costs for shipments crossing borders. However, although this trade barrier explanation is very attractive, the few papers which attempt to explain border effects by (border related) trade barriers generally find poor evidence in favour of the hypothesis (Wei, 1996; Hillberry, 1999; Head and Mayer, 2000).

Using a data set of trade between, and within, the states of the US, Wolf (1997, 2000a,b) shows that border effects also extend to the level of sub-national units, suggesting the existence of additional reasons for 'excessive' local trade. A second explanation could therefore be that intermediate and final goods producers agglomerate in order to avoid trade costs, reducing the need for cross-border trade (Wolf, 1997; Hillberry, 1999; Hillberry and Hummels, 2000). Note that the two explanations are not mutually exclusive, and it could well be that both contribute to the overall effect.

Since the causes of border effects remain unclear, one objective of this paper is to re-examine the various hypotheses underlying the creation of border effects, and in particular to challenge again the trade barriers explanation. Understanding the causes of border effects is of particular interest because it would enable a better evaluation of their welfare implications. If border effects reflect the existence of national trade barriers of some kind, this would indicate that their welfare consequences may well be significant so that there is some room for increased market integration through the removal of those barriers. In contrast, if border effects appear to arise endogenously as a consequence of the optimal location choices of producers, we would conclude that the welfare implications of border effects are probably small.

The case of the European Union (EU) is particularly appealing since the countries within the Union are expected to be highly integrated, and hence should display small border effects. Focusing on seven countries and 78 industries in 1996, the analysis is undertaken in two stages. Firstly, we provide some estimates of border effects at three different levels: the pooled level, the country level and, most interestingly, at industry-specific levels. We stress that the specification of the gravity equation, together with the choice of the distance measure, are crucial for evaluating the size of the border effect.

[1] See, among others, Helliwell (1995, 1997, 1998, 2000), Wei (1996), Hillberry (1999, 2001), Evans (1999, 2001), Wolf (1997, 2000a,b), Cyrus (2000), Helliwell and Verdier (2000), Nitsch (2000a,b), Head and Mayer (2000) and Anderson and van Wincoop (2001).

Secondly, we investigate the role of various border related trade barriers in explaining border effects across manufacturing industries. In particular, we rely on some data on the existence of technical barriers to trade across industries. As far as we know, no previous study has had the opportunity to exploit such data. Our empirical results point to the importance of these barriers in contributing to border effects across industries. In contrast, non-tariff barriers are not significant. Our results also provide some evidence supporting the role of informal barriers to trade, such as product-specific information costs, in explaining border effects. However, these trade costs only provide an incomplete explanation for the presence of border effects since the spatial clustering of firms is also shown to contribute to the overall effect.

The remainder of the paper proceeds as follows: Section 2 presents the model and discusses specification issues. Section 3 describes the data and the econometric methodology implemented. Section 4 provides some estimates for the size of border effects and discusses the results. Finally, Section 5 is devoted to examining the relevance of various elements in explaining border effects across industries. Section 6 concludes.

2. The model

In order to explore the impact of national borders on trade flows, our empirical analysis is based on a standard gravity model since it is the most robust empirical relationship known in explaining the variation of bilateral trade flows. At the industry-level, the gravity model considered here takes the following form:

$$\begin{aligned}\ln X_{ij,k} = {} & \beta_0 + \beta_1 home + \beta_2 \ln Y_{i,k} + \beta_3 \ln Y_j + \beta_4 adj_{ij} \\ & + \beta_5 \ln D_{ij} + \varepsilon_{ij,k}\end{aligned} \tag{1}$$

where i and j indicate the exporting and importing country, respectively, and k the industry. $X_{ij,k}$ is the bilateral export flow expressed in common currency, D_{ij} is the distance between i and j and adj_{ij} is a dummy equal to one when two countries i and j share a common border[2]. As in Evans (1999), Hillberry (1999) and Nitsch (2000a), $Y_{i,k}$ is the production of exporter i in industry k, while Y_j is the importing country's GDP[3]. The parameters to be estimated are denoted by β and $\varepsilon_{ij,k}$ is a Gaussian white noise error term[4].

Since the aim is to compare the relative volumes of intra- versus international trade, the dependent variable includes both international $X_{ij,k}$ $(i \neq j)$ and domestic $X_{ii,k}$ trade observations. As in previous studies (Wei, 1996; Nitsch, 2000a; Evans, 1999, 2001; Head and Mayer, 2000), domestic trade $X_{ii,k}$ for country i is just the difference between its total

[2] This variable is given a value of zero in the case of domestic trade, which is similar to Helliwell (1997) but different from Wei (1996).

[3] See Evans (2001) and Hillberry (2001) for a discussion about the definition of the exporting country's output variable.

[4] We do not include a common language dummy because the countries considered in this paper do not share such a characteristic.

output and its total exports to the rest of the world. The key parameter is then β_1, the coefficient on the *home* dummy variable which is equal to one for domestic trade $(X_{ii,k})$ and to zero for international trade $(X_{ij,k})$. A positive coefficient suggests a preference for trading within the country rather than with other countries. The antilog of β_1 measures the size of the border effect.

As in most studies (one exception is Hillberry and Hummels, 2002), this paper suffers from a lack of information on domestic shipment distances, D_{ii}. This is problematic since the estimated *home* coefficient is known to be extremely sensitive to the way domestic distances are measured[5]. Here, international and intra-national distances are both computed from the weighted averages of the geographic distances between the major cities of each region using regional GDP weights, allowing to emphasize the regions which should be more involved in trade. See Appendix A for details.

Without any evidence on actual shipment distances, arguments about 'correct' measures of distances are obviously meaningless[6]. To check the robustness of our results, we thus consider two alternative measures of internal distances. The first is based on Wei's (1996) method of taking a quarter of the distance to the economic centre of the nearest trading partner, and the second on Leamer (1997) who suggests to take the radius of a circle (whose area is the area of the country). International distances are calculated between the economic centres of each country.

When trade flows are disaggregated at the industry level, the inclusion of distance does not, however, capture that different goods are subject to different transportation costs. Since the weight-to-value ratio of shipments provides a significant explanation of freight rates (Hummels, 1999a,b), both distance and weight-to-value will accordingly be considered as determinants of bilateral trade. Our weight-to-value measure, wv_k, is industry-specific, but averaged across all country pairs ij[7]:

$$wv_k = \left[\frac{\sum_i \sum_j Q_{ij,k}}{\sum_i \sum_j X_{ij,k}}\right] \tag{2}$$

where $Q_{ij,k}$ is the weight of bilateral exports $X_{ij,k}$. Since the freight component of costs is higher for bulky, high weight-to-value raw materials than for manufactures, we expect to find a negative relationship between weight-to-value and bilateral trade.

Finally, Anderson and van Wincoop (2001) show that, in equilibrium, bilateral trade depends on both origin and destination price levels, which are themselves related to the existence of trade barriers ('multilateral resistance'). Our specification of the gravity

5 See Wei (1996), Leamer (1997), Nitsch (2000a), Helliwell and Verdier (2000), Helliwell (2000) and Head and Mayer (2000, 2001) for measuring domestic distances and Nitsch (2000b), Hazledine (2000) and Head and Mayer (2000, 2001) for international distances.

6 Using the 1997 US Commodity Flow Survey, Hillberry and Hummels (2002) find that the actual distances shipped within US states are much shorter than those computed by different authors.

7 We do not consider *bilateral* weight-to-value because: (a) it cannot be computed when trade is zero or domestic and (b) Hillberry and Hummels (2000) show that bilateral weight-to-value significantly falls with distance, suggesting that the commodity composition of trade is sensitive to bilateral trade costs, but also that weight-to-value is endogenous.

equation could therefore lead to biased estimates since relative prices are ignored. Since each partner should have a different price for each commodity, we control for those prices (and for any other regional idiosyncrasies) by including origin and destination fixed-effects, interacted with industry dummies[8].

3. Data sources and methodology

The data come from Eurostat, the Statistical Office of the European Commission. The value of output, bilateral and total exports for manufacturing industries (in thousand ecus), together with the weight of exports (in tons), are available at the four-digit Nace rev.1[9] level. GDPs are also taken from Eurostat.

It would clearly be interesting to estimate border effects through time, but due to data problems[10], our sample is purely cross-sectional for 1996 only. Linking total output with total exports allows us to compute domestic trade $X_{ii,k}$ for seven countries (France, Germany, Italy, the UK, Spain, Finland and Portugal) and 78 industries, leading to $(78 \times 7) = 546$ observations. Bilateral exports between countries and industries represent $(7 \times 6) \times 78 = 3276$ observations. The sample therefore covers a total of 3822 observations.

In our data set, about 5% of bilateral exports are equal to zero (no exports are recorded either because they actually were zero, or because they fell below a reporting threshold). There are various alternatives to tackle this problem. The zeroes can simply be eliminated from the sample and the model estimated by OLS. However, this does not seem appropriate since these omitted observations contain information about why such low levels of trade are observed. We therefore follow Eichengreen and Irwin (1993, 1998) and Boisso and Ferrantino (1997) who express the dependent variable as $\ln(1 + X_{ij,k})$. For high levels of trade flows, $\ln(1 + X_{ij,k}) \simeq \ln(X_{ij,k})$ and for $X_{ij,k} = 0$, $\ln(1 + X_{ij,k}) = 0$. The model can then be estimated by a tobit procedure. The tobit coefficients are not direct estimates of the elasticities, but those at sample means can be recovered by the McDonald and Moffitt (1980) procedure.

Finally, since exporters' output $Y_{i,k}$ may be endogenous, we instrumented this variable by the number of workers, but based on a Hausman specification test, the hypothesis of exogeneity could not be rejected at standard significance levels. Accordingly, exporters' output is treated as exogenous.

4. The magnitude of border effects

The estimation of Eq. (1) over the pooled sample allows us to assess the average border effect value for our seven EU countries and 78 industries. Table 1 reports the elasticities at

[8] See Hummels (1999a), Hillberry and Hummels (2002) and Rose and van Wincoop (2001).

[9] Nace rev.1 is the General Industrial Classification of Economic Activities within the European Union.

[10] Before 1995, output data at the sectoral level was only collected for undertakings with 20 or more persons employed. In addition, due to the Single Market, the abolition of customs for intra-EU trade has led to changes in trade statistics since 1993.

Table 1
Average and country-specific border effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln $Y_{i,k}$	1.11^{a} (62.44)	1.13^{a} (60.50)	1.13^{a} (62.04)	–	–	–	–	–	–
ln Y_j	0.53^{a} (20.52)	0.57^{a} (20.74)	0.58^{a} (21.73)	–	–	–	–	–	–
adj_{ij}	0.12 (1.32)	0.83^{a} (9.34)	0.73^{a} (8.33)	0.16^{b} (2.09)	0.54^{a} (7.12)	0.59^{a} (7.83)	0.10 (1.15)	0.74^{a} (9.42)	0.74^{a} (9.42)
ln D_{ij}	-1.46^{a} (−25.37)	-1.10^{a} (−17.53)	-1.22^{a} (−19.91)	-1.68^{a} (−34.34)	-1.39^{a} (−25.05)	-1.33^{a} (−25.66)	-1.38^{a} (−22.37)	-0.88^{a} (−13.93)	-0.88^{a} (−13.93)
ln wv_k	-0.56^{a} (−28.86)	-0.56^{a} (−27.70)	-0.56^{a} (−27.99)	-0.67^{a} (−14.02)	-0.67^{a} (−13.24)	-0.67^{a} (−13.28)	-0.67^{a} (−14.30)	-0.67^{a} (−13.79)	-0.67^{a} (−13.79)
home	1.80^{a} (11.97)	2.43^{a} (14.00)	3.23^{a} (25.94)	1.32^{a} (10.72)	1.71^{a} (11.62)	3.06^{a} (31.02)	–	–	–
$home_{GER}$	–	–	–	–	–	–	0.94^{a} (5.20)	1.39^{a} (6.95)	2.45^{a} (14.98)
$home_{UK}$	–	–	–	–	–	–	1.17^{a} (6.20)	2.02^{a} (10.18)	3.07^{a} (18.68)
$home_{FR}$	–	–	–	–	–	–	1.96^{a} (10.32)	2.21^{a} (10.14)	3.47^{a} (19.72)
$home_{IT}$	–	–	–	–	–	–	2.01^{a} (10.75)	2.38^{a} (10.92)	2.88^{a} (14.85)
$home_{PO}$	–	–	–	–	–	–	2.05^{a} (8.07)	4.15^{a} (17.40)	4.42^{a} (19.70)
$home_{SP}$	–	–	–	–	–	–	2.20^{a} (11.44)	3.14^{a} (15.83)	3.51^{a} (19.08)
$home_{FI}$	–	–	–	–	–	–	3.65^{a} (13.76)	5.25^{a} (18.62)	6.29^{a} (28.07)
Distance measure	Own	Wei	Leamer	Own	Wei	Leamer	Own	Wei	Leamer
Fixed-effects	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2	0.272	0.257	0.261	0.414	0.392	0.393	0.421	0.408	0.408

Notes: Tobit estimations, sample mean elasticities, N=3822. t-values are reported in parentheses; [a, b, c] denote significance at the 1%, 5% and 10% levels, respectively; 'fixed-effects' indicates whether industry by region fixed-effects are included. Abbreviations for the countries are as follows: FR, France; GER, Germany; IT, Italy; SP, Spain; FI, Finland; PO, Portugal.

sample means calculated by the McDonald and Moffitt (1980) procedure, but the *t*-statistics are given for the estimated coefficients.

From the basic gravity equation estimated with our distance measure (column (1)), the *home* coefficient is highly significant and equal to 1.80, suggesting that a EU country trades about six times [= exp(1.80)] more with itself than with a foreign EU country, after adjusting for a number of factors. The use of Wei and Leamer distances (columns (2) and (3)) increases substantially the estimated *home* coefficient, which therefore appears to be extremely sensitive to the way distances are measured.

In columns (4) to (6), origin and destination fixed-effects across industries are then included in order to control for omitted relative prices (note that their inclusion precludes from the estimation of exporter output and importer income coefficients). In all three regressions (which use alternative distance measures), the economic impact of crossing the border is greatly reduced. This finding lends support to the results obtained by Anderson and van Wincoop (2001) in that omitting relative prices leads to over-estimate the border effect. See also Hillberry and Hummels (2002).

In all specifications, the basic 'gravity' explanatory variables are highly significant and display coefficients with the expected signs (except for adjacency in column (1)). Weight-to-value displays a negative and highly significant coefficient, suggesting, as expected, that a high weight-to-value decreases bilateral trade. In column (4), the coefficient on our distance measure (equal to -1.68) is larger than the one on Wei (-1.39) or Leamer (-1.33) distances, but all three coefficients are larger than those reported in many studies (usually -0.6). Some authors argue that a distance coefficient close to unity (in absolute value) is far too large to be explained (Hazledine, 2000; Grossman, 1998). Theory however shows that the elasticity of trade with respect to distance is given by the elasticity of substitution between products times the elasticity of trade costs with respect to distance (Anderson and van Wincoop, 2001). As a result, arguing that the coefficient is too large or too small is obviously not possible without knowing the values of the two factors.

We now turn to the analysis of border effects across countries. To do so, the *home* dummy is replaced by country-specific *home* dummies so that seven *home* coefficients are now estimated. The results are reported in the three last columns of Table 1, whose specifications differ only in terms of the distance measure used.

When using our distances (column (7)), Germany and the UK display the smallest *home* coefficients (0.94 and 1.17, respectively). These two countries are followed by France (1.96), Italy (2.01), Portugal (2.05), Spain (2.20) and finally Finland (3.65). In columns (8) and (9), where Wei and Leamer distances are used, all *home* coefficients are larger, but the *ranking* of countries remains very similar: Germany always displays the smallest and Finland the largest *home* coefficient. The choice of the distance measure therefore affects the *size* of the *home* coefficients, but not necessarily the *ranking* of countries.

The late accessions of Spain, Portugal (in 1986) and Finland (in 1995) to the EU may be a possible reason for their larger border effects and hence for their apparent lower degree of market integration. However, country size seems to matter since the smallest countries such as Finland or Portugal display the largest effects. This is consistent with Anderson and van Wincoop (2001) who argue that smaller countries should display larger border effects because a small drop in international trade can lead to a much larger increase in trade within a small country than within a large one.

Border effects also differ across industries. Table 2 reports the results of estimating industry-specific gravity equations. Weight-to-value is now omitted (since its variation is soaked out by the intercepts), but exporting and importing country fixed-effects are included. Sectors are ordered in terms of decreasing magnitude of border effects. The coefficients on distance and adjacency (not reported) are not systematically significant. However, when they are, the coefficients usually display the expected signs.

When using our distances (column (1)), the largest *home* coefficient, which is equal to 19.17, is found for ready-mix concrete. It should be noted that among the 42 bilateral trade observations ($i \neq j$) included in the sample for that industry, positive trade flows are recorded in 11 cases only (column (4)), reflecting the domestic orientation of that industry. The geographic market for ready-mix concrete is, indeed, very local, since the perishable nature of such a 'wet' product constrains the distance over which it can be delivered. Ready-mix concrete is also the less transportable product of the sample with a weight-to-value of 35 kilos per ecu (column (5))[11].

Large *home* coefficients are found in many other cases: 5.52 for carpentry and joinery, 4.19 for mortars, 3.76 for printing, 3.27 for metal structures and 3.06 for corrugated paper. At the opposite end of the spectrum, border effects are not significantly different from zero in a number of industries such as oils and fats or games and toys. Finally, in the case of aluminium, the negative and significant (at the 10% level) coefficient on the *home* variable suggests a preference for trading with other countries rather than with itself.

Table 2 also reports the industry-specific *home* coefficients estimated when using Wei or Leamer distances (columns (2) and (3)). Consistent with our previous findings, ready-mix concrete always displays the largest coefficient. Also, the coefficients obtained with Wei or Leamer distances are in general larger than our coefficients. But most importantly, the *ranking* of the various industries remains very similar: the correlation between our coefficients and those obtained with Wei's distances is equal to 0.98, and to 0.93 with those obtained with Leamer's distances. Those findings highlight that the choice of the distance measure affects the magnitude of the estimates, while the ranking across industries remains similar[12].

The main findings of this section are as follows. Firstly, controlling for relative prices reduces the size of border effects. Secondly, the way distances are computed affects the size of border effects, while their ranking across countries or industries remains similar.

5. Explaining border effects

Our results show that border effects vary across industries. We now analyse the factors which may explain these industry-specific border effects.

[11] Note that in 1994, the European concrete industry was taken to the European Court of Justice because of collusion practices, so the excessively large border effect found for concrete probably also captures the organization of the industry at that time.

[12] When excluding ready-mix concrete, which is clearly an outlier in the sample, the correlation between our coefficients and those obtained with Wei's distances is equal to 0.94, and to 0.76 with those obtained with Leamer's distances.

Table 2
Industry-specific border effects

Industry	Own distances	Wei's distances	Leamer's distances	No. of zero obs.	wv_k (kg/ecu)
Ready-mix concrete	19.17[a]	18.13[a]	17.54[a]	31	35.14
Carpentry and joinery	5.52[a]	5.92[a]	6.25[a]	0	0.47
Mortars	4.19[b]	4.79[a]	7.48[a]	16	4.64
Printing	3.76[a]	4.28[a]	5.20[a]	0	0.45
Metal structures	3.27[a]	3.17[a]	4.39[a]	1	0.59
Corrugated paper	3.06[a]	3.44[a]	4.62[a]	0	0.72
Publishing of books	2.85[a]	3.74[a]	4.34[a]	0	0.18
Concrete products	2.85[a]	3.56[a]	5.90[a]	4	6.31
Carpets and rugs	2.70[a]	2.38[a]	3.31[a]	0	0.32
Other products of food	2.66[a]	3.58[a]	4.50[a]	0	0.58
Other plastic products	2.25[a]	2.62[a]	3.43[a]	0	0.18
Processing of fruit and vegetables	2.21[a]	2.69[a]	3.71[a]	1	1.27
Footwear	2.19[b]	2.79[a]	3.26[a]	0	0.05
Television and radio	2.10[b]	2.49[a]	2.73[a]	0	0.01
Stone	2.00[b]	2.37[a]	4.20[a]	2	2.13
Veneer sheets	1.93[a]	1.96[a]	2.97[a]	0	2.03
Tools	1.85[a]	1.76[a]	2.73[a]	0	0.06
Tanks, reservoirs	1.73	1.96	3.63[a]	4	0.30
Fruit and vegetables	1.70	1.85	4.16[a]	5	1.14
Hollow glass	1.70[a]	1.77[a]	3.00[a]	0	1.17
Pharmaceutical preparations	1.69[b]	2.38[b]	2.95[a]	0	0.03
Other furniture	1.66[b]	2.85[a]	3.72[a]	0	0.38
Office and shop furniture	1.65[a]	1.78[b]	3.70[a]	1	0.26
Beer	1.64	1.52	4.27[a]	4	2.06
Ware of plastic	1.62[b]	2.14[b]	3.59[a]	1	0.31
Machinery for metallurgy	1.59	1.40	2.93[a]	4	0.30
Sawmilling and planing of wood	1.56	2.95[b]	3.84[a]	1	3.45
Other outerwear	1.47[c]	1.84[c]	2.97[a]	0	0.04
Ceramic sanitary	1.46	1.13	3.79[a]	6	0.42
Other manufacturing	1.28[c]	1.85[b]	2.44[a]	0	0.13
Paints, varnishes	1.23	1.57	2.98[a]	0	0.47
Electric domestic appliances	1.23[a]	1.20[a]	2.04[a]	0	0.18
Organic basic chemicals	1.22[b]	0.85	1.81[a]	0	1.25
Rubber products	1.18[c]	1.47[c]	2.50[a]	0	0.22
Iron and steel	1.17[b]	1.31[b]	2.45[a]	0	2.87
Engines and turbines	1.14	1.36	2.27[a]	2	0.05
Screw machine products	1.13	1.60[c]	2.45[a]	0	0.33
Machinery for paper	1.12[c]	1.85[a]	2.16[a]	0	0.07
Lifting and handling equipment	1.07	1.19	2.34[a]	1	0.16
Medical equipment	1.07	1.21	1.96[a]	0	0.02
Cocoa, chocolate and sugar	1.03	1.61	3.05[a]	2	0.38
Other purpose machinery	0.92[c]	1.12[b]	1.98[a]	0	0.07
Other metal products	0.91	1.41[c]	2.36[a]	0	0.30
Wire and cable	0.90	1.51	2.66[a]	1	0.21
Cooling and ventilation	0.90	1.41[c]	2.48[a]	0	0.09
Dairies and cheese	0.89	1.45	3.42[a]	1	0.78
Plastic packing goods	0.86	1.60	2.82[a]	0	0.39
Rusks and biscuits	0.86	1.23	2.95[a]	0	0.41

(continued on next page)

Table 2 (*continued*)

Industry	Own distances	Wei's distances	Leamer's distances	No. of zero obs.	wv_k (kg/ecu)
Machine-tools	0.85[b]	0.74[c]	1.73[a]	0	0.07
Abrasive products	0.83	1.14	2.09[a]	0	0.14
Bodies for motor vehicles	0.78	1.39	2.92[a]	1	0.22
Plastic plates	0.77[c]	1.18[c]	2.25[a]	0	0.35
Chairs and seats	0.68	1.46	2.86[a]	0	0.16
Lighting equipment	0.66	1.41[c]	2.26[a]	0	0.09
Luggage, handbags	0.58	1.43	2.35[a]	0	0.06
Other agricultural machinery	0.54	1.31	2.48[a]	1	0.18
Ice cream	0.52	0.84	3.45[a]	5	0.42
Plaster products	0.47	2.76	6.15[a]	16	6.16
Meat	0.40	0.78	2.82[a]	1	0.54
Taps and valves	0.37	0.97	1.79[a]	1	0.06
Other purpose machinery	0.36	1.03	1.82[a]	0	0.06
Machinery for mining	0.19	0.35	1.42[a]	0	0.20
Machinery for food	0.16	0.43	2.25[a]	1	0.06
Locks and hinges	0.13	0.38	2.02[a]	0	0.14
Brooms and brushes	0.06	0.82	2.52[a]	3	0.11
Plastics	0.05	0.30	1.71[a]	0	0.92
Other food products	−0.03	0.58	2.50[a]	1	0.29
Alcoholic beverages	−0.17	−0.34	1.79[a]	1	0.33
Bearings, gears	−0.20	−0.09	1.18[c]	1	0.11
Pumps and compressors	−0.51	−0.22	0.93	1	0.07
Explosives	−0.78	0.20	3.22[a]	10	0.16
Copper	−0.89	−0.21	1.24[b]	1	0.46
Radiators and boilers	−0.92	0.89	3.04[b]	5	0.32
Fish	−0.93	−1.34	1.79[b]	2	0.43
Oils and fats	−1.57	−0.07	2.80[b]	6	2.68
Games and toys	−1.75	−1.05	0.69	0	0.11
Agricultural tractors	−1.81	−1.89	0.24	5	0.16
Aluminium	−1.84[c]	−0.94	1.04	2	0.70

Notes: Depending on the number of zeroes out of 49 observations in each industry-specific sample (column (4)), method of estimation is tobit or OLS (White); [a, b, c] denote significance at 1, 5 and 10% levels, respectively.

Theory shows that the border effect is equal to the product of two factors: the degree of substitutability between goods produced in different countries and the tariff equivalent of the border barrier (Wei, 1996; Evans, 1999, 2001; Hillberry and Hummels, 2000; Anderson and van Wincoop, 2001). On the one hand, border effects can arise because the high degree of substitution between domestic and imported goods may lead to a high responsiveness of trade flows even in the case of very modest trade barriers. For instance, Table 2 emphasizes that bulk commodities like concrete, stone, concrete products or mortars have some of the highest border effects, but home and foreign varieties are also likely to be highly substitutable.

On the other hand, for a given value of the elasticity of substitution, any industry characteristic that affects the border barrier would be a good candidate to explain border effects. However, as already discussed, the results reported so far remain disappointing when attempting to explain border effects by border related barriers. Wei

(1996) examines whether the impact of borders can be attributed to exchange rate volatility between OECD countries, but finds no significant effect. Head and Mayer (2000) show that non-tariff barriers do not explain border effects in Europe. Using the estimates of commodity-specific border effects for 136 products traded between Canada and the US in 1993, Hillberry (1999) investigates the role of trade policy (tariffs), regulations, information and communication costs (captured by the extent of multinational activity), product-specific information costs, public procurement and hysteresis in domestic transportation networks, but none of these appears significant in explaining border effects.

One objective of this section is hence to challenge the border barriers explanation of border effects. To do so, we analyse the role of technical barriers to trade (TBTs). Note that the role of TBTs has not been investigated previously. As quoted by Hillberry (1999, p. 35), due to data unavailability, "[TBT]-related explanations of border effects must be relegated to anecdotal evidence". Non-tariff barriers (NTBs) are also considered. Finally, the role of product-specific information costs is explored. In particular, if it is more costly to obtain some information about the quality, or even the existence, of a foreign product as compared to a domestic product, we would expect this higher cost to reduce the quantities of foreign goods purchased (Rauch, 1999), and hence to contribute to the existence of border effects.

An alternative explanation could be that border effects arise endogenously. The intuition is that in order to avoid trade costs, intermediate and final goods producers tend to agglomerate, generating endogenous border effects because intermediate goods trade is essentially local and within borders. Wolf (1997, 2000b) points out that intermediate goods trade generally covers shorter distances than does final goods trade, leading him to argue that the clustering of intermediate stages of production might explain the large coefficients on the *home* dummy variable. Hillberry (1999) and Hillberry and Hummels (2000) also show that the spatial clustering of firms magnifies border effects. Accordingly, the present paper also checks for whether this alternative explanation for border effects can be validated by the data when focusing on the European Union case.

We decide to group the various possible explanations for border effects into two broad categories: technical and non-tariff barriers to trade, together with product-specific information costs, are defined as 'trade costs', whereas the spatial agglomeration of firms and the elasticity of substitution among varieties are considered as 'behavioural responses to trade costs'.

The next four sections are devoted to our analysis. The first section motivates the choice of trade cost variables in explaining border effects. The second further extends the analysis by considering behavioural responses to trade cost variables. The main results are reported in the third section. Finally, some robustness checks are provided in the last section.

5.1. Trade cost variables

In the context of achieving the free trade objectives of the Single Market Programme in Europe, the Mutual Recognition Principle (MRP) states that products manufactured and sold in one EU country should be lawfully accepted for sale in all other member states. However, member states have the right to restrict intra-EU imports on the grounds of health, safety, environmental and consumer protection. These obstacles, known as technical barriers to trade (TBTs), impose some additional costs on exporters who want to access foreign markets, and could hence contribute to border effects. Various measures were implemented in order to remove these barriers[13], but in 1996, about 79% of intra-EU goods trade were still affected by TBTs (European Commission, 1998).

In order to investigate whether TBTs have an impact on border effects, we rely on a study undertaken for the European Commission (European Commission, 1998) which identifies the industries affected by TBTs and assesses, on a five-point scale, the effectiveness of different measures undertaken: (1) no solution has been adopted, (2) measures are proposed or implemented, but not effective or with operating problems, (3) measures are adopted, but with implementation or transitional problems still to be overcome, (4) measures are implemented and function well, but some barriers remain, and (5) measures are successful and all significant barriers are removed. The study also identifies some industries which, prior to European integration, were not affected by TBTs. This information allows us to compute, for the sample of industries affected by TBTs, an industry-specific qualitative variable, tbt_k, taking values between one and five with a larger value indicating an increase in market integration due to removed TBTs.

The choice of this variable might be criticized on the grounds that it captures changes in border costs rather than levels. For instance, it could be that TBTs were decreased in an industry k (so that tbt_k is equal to four), but that the *level* of TBTs continues to be higher than in other industries where no solution was adopted (and where tbt_k is equal to one). Then, tbt_k would obviously provide some biased information about the level of TBTs. To address this issue, we compute a second variable, tbt_k^*, which is a dummy equal to one when: (a) industry k was *not* affected by TBTs prior to European integration and (b) the measures implemented were successful and all barriers are removed (that is, when tbt_k is equal to five), and zero otherwise. In other words, tbt_k^* distinguishes the industries with no TBTs (either because TBTs do not occur or were eliminated) from those where some barriers persist (whatever the level of those barriers).

We expect those industries with no TBTs, or with TBTs removed, to display smaller border effects. In the case of ready-mix concrete, the value of 2 for tbt_k, which indicates that this industry continues to be affected by TBTs, may provide an explanation for some of its large border effect, with the opposite holding true for games and toys which are given a value of 5. In addition, locks and hinges and brooms and brushes, which do not display any border effect, are some of the industries where TBTs do not occur.

Next, we consider a measure reflecting the importance of non-tariff barriers (NTBs) across industries. The intuition is that if goods are required to meet certain standards, these

[13] The ‘Old Approach’ and ‘New Approach’ to technical harmonisation in particular. See European Commission (1998) for details.

may act as a tariff or a quota in reducing or even eliminating foreign competition for domestic producers, so that industries subject to non-tariff barriers are expected to display larger border effects. The extent to which a sector k is affected by non-tariff barriers is captured by a qualitative variable ntb_k which ranges between 1 and 3 (European Commission (1997))[14]. For instance, the extent of non-tariff barriers for television and radio or pharmaceutical preparations (ntb_k equals 3) could be a possible reason for their large border effects.

It is worth noting that the non-availability of cross-country indicators on NTBs or TBTs is clearly a shortcoming of this empirical study. Despite the EU integration process, cross-country differences in NTBs or TBTs continue to exist, and should therefore be considered in explaining border effects.

Finally, it can be expected that product-specific information costs may also play a role in explaining border effects. In particular, cost differences to obtain information about the existence or quality of foreign products may represent informal barriers to trade. In this context, Rauch (1999) stresses the role of 'search costs' as a barrier to trade for differentiated products by providing evidence that much international exchange in differentiated products takes place across networks of trading contacts, the extent of which is determined in part by search-reducing proximity, common language and common understanding of legal and cultural institutions. We therefore make use of Rauch's (1999) US four-digit SITC Rev.2 categorisation of industries according to three possible types: homogeneous goods (products traded on 'organised exchange' markets), reference priced (products quoted in trade publications) and differentiated products[15]. According to Rauch (1999), we would expect that 'search costs' are higher for differentiated products and, therefore, contribute to larger border effects. To check this assumption, three dummy variables (n for differentiated products, r for reference priced and w for homogeneous goods) are computed, each characterizing the three industry types. If Rauch's (1999) hypothesis is correct, we would expect border effects to be larger in n-type industries, smaller in r-type ones, and finally to be the smallest for w-type industries.

5.2. Behavioural responses to trade cost variables

The clustering of firms may provide an additional explanation for the existence of border effects. In order to investigate this hypothesis, Hillberry (1999) uses an index of 'geographic concentration' computed by Ellison and Glaeser (1997) for US industries at the four-digit SIC level. The index measures the extent to which firms' production is tied to any particular geographic location (because firms require natural resources or benefit from agglomeration externalities). A low value for the index indicates that the industry in question is not reliant on a specific geographic location, whereas industries

[14] This non-tariff barriers variable captures differences in standards, national preference in public purchases and customs formalities. In contrast, TBTs essentially refer to technical regulations imposed by national governments for health, safety, environmental and consumer protection.

[15] This is available at http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html#Rauch. Note that Rauch provides two classifications, 'conservative' and 'liberal'.

which require to produce in specific locations display high values. If some firms are *not* attached to any specific location (a low value for the index), it can be expected that they will choose their location of production so as to minimise cross-border transaction costs, and as a result, border effects could be magnified. The size of the border effect is therefore expected to be inversely related to the Ellison and Glaeser (1997) index.

To check for this possibility, the industry-specific indices reported in the unpublished appendix of Ellison and Glaeser (1994) are matched with our European industries. We believe that their data, though measured with US data, can provide some information about the distribution of European industries. For instance, if the US wine industry is highly dependent on specific locations due to the natural advantages of some regions in growing grapes, the European wine industry is naturally expected to share the same features. Of course, it would be better to exploit European data, but the computation of such indices is well beyond the scope of this paper.

On the whole, the smaller the value of the index (denoted by co_k), the more likely the border effect for the corresponding industry should be larger. For instance, ready-mix concrete (SIC 3273) displays, in the US, a small index of 0.010, whereas for copper (SIC 3331), the high value of 0.194 suggests that this industry is highly dependent on specific locations. This pattern of the indices across both US industries could therefore be taken as prima facie evidence that some of the EU border effects obtained for the corresponding industries are, to some extent, endogenous.

Finally, the elasticity of substitution among varieties is another potential explanation for border effects. In order to investigate this possible relationship, the elasticity of substitution corresponding to each commodity would be required. But as shown by Hummels (1999a), this elasticity can only be identified when some components of trade costs, such as tariffs, are directly observable. This is not possible here.

Another way to address this issue is to compare distance coefficients across commodities[16]. Since those coefficients are given by the elasticity of substitution times the elasticity of trade costs with respect to distance, we cannot identify the values of the two factors. Nevertheless, we could expect distance and *home* coefficients to be highly (and negatively) correlated if the elasticity of substitution is indeed a large part of the explanation for border effects. The correlation between *home* and distance coefficients (not reported) is however positive and equal to 0.48, suggesting that the elasticity of substitution is not driving the cross-industry variance in border effects. This is contrary to Evans (1999) who finds that border effects are largely explained by the elasticity of substitution across varieties.

5.3. Results

We now examine the relationship between the variables and border effects. To do so, the gravity equation is estimated over the pooled sample of countries and industries, including the *home* variable and an interaction term between *home* and the

[16] We thank an anonymous referee for this suggestion.

explanatory variable of interest (as in Evans, 1999). Since the aim is to compare border effects across industry types, industry-specific distance interaction terms are included, together with industry-specific origin and destination fixed-effects $a_{i,k}$ and $a_{j,k}$. The specification is[17]:

$$\ln(1+X_{ij,k}) = a_{i,k} + a_{j,k} + \gamma_1 home + \gamma_2 (home \times vi_k) + \gamma_3 adj_{ij} + \sum_k \gamma_k \ln D_{ij} + \varepsilon_{ij,k} \tag{3}$$

The sign and significance of the γ_2 coefficient on the interaction term indicates whether industries with a particular characteristic vi_k display larger or smaller border effects. In addition, the magnitude of the *home* and of the interaction coefficients, γ_1 and γ_2, permits to assess the relative importance of each explanatory factor vi_k. In this section, we only focus on the results obtained with our distance measure.

Is there any evidence that border effects are explained by technical barriers to trade? The results with the tbt_k variable are reported in column (1) of Table 3 (the sample is restricted to those industries which were affected by TBTs, i.e. $N=3185$). The negative and significant coefficient on the interaction term with tbt_k shows that industries where TBTs were removed display smaller border effects. The coefficients on *home* (3.80) and on the interaction term (-0.67) further indicate that industries where TBTs are eliminated ($tbt_k = 5$) have a *home* coefficient of $(3.80-(0.67\times 5)) = 0.45$, whereas on the contrary, industries where no solution was adopted ($tbt_k = 1$) have a coefficient of $(3.80-(0.67\times 1)) = 3.13$. For the other intermediate industries, which are given a value of 2, 3 and 4 for tbt_k, *home* coefficients lie between 0.45 and 3.13. The results suggest that deeper market integration, in the form of reduced TBTs, reduces the impact of borders on trade flows.

From column (2), when using the tbt_k^* measure, we see that industries with no TBTs ($tbt_k^*= 1$) generally display smaller border effects: their *home* coefficient is equal to $(1.54-(0.60\times 1)) = 0.94$ against $(1.54-(0.60\times 0)) = 1.54$ for industries where some barriers remain (that is, all those industries with a tbt_k value of 1, 2, 3 and 4). Given that tbt_k and tbt_k^* yield comparable results, we conclude that tbt_k does provide some general information about the extent of TBTs across industries.

The results on non-tariff barriers are reported in column (3). The positive but insignificant coefficient on the interaction term implies that non-tariff barriers do not matter in explaining border effects, a finding consistent with that by Head and Mayer (2000).

Spatial clustering is explored in column (4). As expected, firms with a small value of the Ellison and Glaeser (1997) index display larger border effects. This lends support to the arguments by Wolf (1997, 2000a,b), Hillberry (1999) and Hillberry and Hummels (2000) in that firms not tied to any specific location probably locate so as to minimise trade costs. As a result, international trade is reduced and border effects appear endogenously.

[17] Note that with industry-specific distance interaction terms, weight-to-value is now omitted because of a multicollinearity problem (its coefficient changes sign).

Table 3
Explaining border effects (dependent variable is $\ln(1 + X_{ij,k})$, own distance measure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
adj_{ij}	0.19[b] (2.45)	0.17[b] (2.46)	0.17[b] (2.45)	0.17[b] (2.50)	0.17[b] (2.45)	0.17[b] (2.45)	0.17[b] (2.45)	0.17[b] (2.45)	0.19[b] (2.49)	0.17[b] (2.50)
$\ln D_{ij}$	−1.80[a] (−26.64)	−1.76[a] (−27.56)	−1.76[a] (−27.47)	−1.77[a] (−28.07)	−1.77[a] (−27.64)	−1.76[a] (−27.49)	−1.77[a] (−27.50)	−1.77[a] (−27.64)	−1.79[a] (−26.96)	−1.77[a] (−28.08)
home	3.80[a] (17.50)	1.54[a] (13.24)	1.25[a] (6.81)	−0.51[a] (−2.72)	1.38[a] (12.41)	1.26[a] (11.23)	1.17[a] (8.90)	–	–	–
$home \times tbt_k$	−0.67[a] (−14.01)	–	–	–	–	–	–	–	−0.70[a] (−12.26)	–
$home \times tbt_k^*$	–	−0.60[a] (−6.19)	–	–	–	–	–	–	–	−0.35[a] (−3.20)
$home \times ntb_k$	–	–	0.02 (0.28)	–	–	–	–	–	−0.16 (−1.62)	−0.10 (−1.13)
$home \times \ln co_k$	–	–	–	−0.45[a] (−11.72)	–	–	–	–	−0.35[a] (−7.90)	−0.42[a] (−10.31)
$home \times w$	–	–	–	–	−0.60[a] (−4.38)	–	–	0.78[a] (4.86)	3.22[a] (7.81)	−0.16 (−0.53)
$home \times r$	–	–	–	–	–	0.24[c] (1.87)	–	1.50[a] (9.78)	2.89[a] (7.18)	−0.13 (−0.44)
$home \times n$	–	–	–	–	–	–	0.19[c] (1.79)	1.36[a] (11.86)	2.62[a] (7.25)	−0.04 (−0.16)
N	3185	3822	3822	3822	3822	3822	3822	3822	3185	3822
pseudo-R^2	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46

Notes: Tobit estimations, sample mean elasticities. Industry-specific distance interaction terms (meat is the excluded industry), and industry-specific origin and destination fixed-effects are included (not reported); *t*-values are reported in parentheses; [a, b, c,] denote significance at 1%, 5% and 10% levels, respectively. The probabilities associated with the hypotheses that *w* and *r* effects, *r* and *n* effects, and *w* and *n* effects, are equal are, respectively, 0.00, 0.27 and 0.00 in column (8), 0.07, 0.07 and 0.00 in column (9) and 0.88, 0.50 and 0.45 in column (10).

In our sample of industries, the Ellison and Glaeser (1997) index varies between 0.001 for corrugated paper and 0.378 for carpets and rugs. This means that for an industry with an index of 0.001, the *home* coefficient would, on average, be equal to $(-0.51 - (0.45 \times \ln 0.001)) = 2.60$ while for an industry with an index of 0.378, the *home* coefficient would be $(-0.51 - (0.45 \times \ln 0.378)) = -0.07$.

Columns (5) to (8) show that product-specific information costs are also relevant in explaining border effects[18]: from columns (5) to (7), *w*-type industries display smaller border effects; in contrast, *r*- and *n*-type industries display larger effects. In column (8), when replacing the aggregate *home* dummy by one dummy specific to each industry type, the *home* coefficients for reference priced *r* and differentiated products *n*, respectively equal to 1.50 and to 1.36, are both significantly larger than the one for *w*-type industries (equal to 0.78): the probability associated with the hypotheses that the coefficients on *w*- and *r*-type industries, and on *w*- and *n*-type industries, are equal is equal to zero, but we cannot reject the hypothesis that the coefficients on *r*- and *n*-type industries are equal (the probability is 0.27). We therefore conclude that information costs matter for both reference priced and differentiated products, and as a result, border effects are increased. So despite the use of crude data to check for the role of product-specific information costs (dummy variables only), our results are consistent with those of Rauch (1999). They contradict those of Evans (1999) who shows that a higher degree of product differentiation is associated with a smaller border effect, and those of Hillberry (1999) who finds that product-specific information costs are irrelevant.

Finally, in columns (9) and (10), all interaction variables are included jointly in a single regression. The significance and signs of the coefficients on both TBT variables and on spatial agglomeration are preserved. Non-tariff barriers now display a negative but insignificant coefficient. Product-specific information costs are however not significant anymore, probably because of multicollinearity issues.

5.4. Sensitivity analysis

It might be useful to provide some robustness checks for the results presented so far. Tables 4 and 5 report the results of estimating Eq. (3), but with alternative measures of distances. Again, technical barriers to trade, product-specific information costs and spatial clustering are in general significant in explaining border effects while non-tariff barriers are not.

Another way to examine the role of the various factors in explaining border effects is to regress directly the industry-specific *home* coefficients estimated in the previous section on the various independent variables. Though not ideal from an empirical viewpoint (Hillberry (1999) for a discussion), this method has been used by a number of authors (Head and Mayer, 2000; Cyrus, 2000; Hillberry, 1999). In addition, it provides another robustness check for the results obtained so far. The equation, to estimate, takes the form:

$$\hat{\beta}_{1,k} = c + X\alpha + \eta_k \qquad (4)$$

[18] This is obtained with Rauch's (1999) 'conservative' classification of sectors.

Table 4
Explaining border effects (dependent variable is $\ln(1 + X_{ij,k})$, Wei's distance measure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
adj_{ij}	0.54^{a} (7.22)	0.54^{a} (8.13)	0.54^{a} (8.10)	0.54^{a} (8.19)	0.54^{a} (8.12)	0.54^{a} (8.11)	0.54^{a} (8.10)	0.54^{a} (8.12)	0.54^{a} (7.27)	0.54^{a} (8.21)
$\ln D_{ij}$	-1.55^{a} (−17.05)	-1.50^{a} (−17.28)	-1.51^{a} (−17.33)	-1.53^{a} (−17.76)	-1.54^{a} (−17.63)	-1.52^{a} (−17.37)	-1.52^{a} (−17.38)	-1.54^{a} (−17.64)	-1.55^{a} (−17.13)	-1.53^{a} (−17.66)
home	3.82^{a} (15.70)	1.93^{a} (14.21)	1.64^{a} (8.00)	0.10 (0.49)	1.78^{a} (13.59)	1.63^{a} (12.41)	1.58^{a} (10.48)	–	–	–
$home \times tbt_k$	-0.57^{a} (−10.96)	–	–	–	–	–	–	–	-0.57^{a} (−9.17)	–
$home \times tbt_k^{*}$	–	-0.60^{a} (−5.72)	–	–	–	–	–	–	–	-0.37^{a} (−3.10)
$home \times ntb_k$	–	–	0.03 (0.27)	–	–	–	–	–	−0.15 (−1.36)	−0.09 (−0.98)
$home \times \ln co_k$	–	–	–	-0.40^{a} (−9.44)	–	–	–	–	-0.29^{a} (−5.93)	-0.35^{a} (−7.90)
$home \times w$	–	–	–	–	-0.65^{a} (−4.39)	–	–	1.13^{a} (6.24)	3.13^{a} (6.89)	0.44 (1.36)
$home \times r$	–	–	–	–	–	0.33^{b} (2.42)	–	1.96^{a} (11.36)	3.10^{a} (7.01)	0.66^{b} (2.05)
$home \times n$	–	–	–	–	–	–	0.15 (1.35)	1.73^{a} (12.97)	2.81^{a} (7.03)	0.62^{b} (2.14)
N	3185	3822	3822	3822	3822	3822	3822	3822	3185	3822
pseudo-R^2	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.45

Notes: Tobit estimations, sample mean elasticities. Industry-specific distance interaction terms (meat is the excluded industry), and industry-specific origin and destination fixed-effects are included (not reported); *t*-values are reported in parentheses; [a, b, c,] denote significance at 1%, 5% and 10% levels, respectively. The probabilities associated with the hypotheses that *w* and *r* effects, *r* and *n* effects, and *w* and *n* effects, are equal are, respectively, 0.00, 0.10 and 0.00 in column (8), 0.90, 0.06 and 0.08 in column (9) and 0.26, 0.75 and 0.28 in column (10).

Table 5
Explaining border effects (dependent variable is $\ln(1+X_{ij,k})$, Leamer's distance measure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
adj_{ij}	0.57[a]	0.59[a]	0.59[a]	0.59[a]	0.59[a]	0.59[a]	0.59[a]	0.59[a]	0.57[a]	0.59[a]
	(7.67)	(8.67)	(8.63)	(8.76)	(8.65)	(8.63)	(8.63)	(8.65)	(7.76)	(8.77)
$\ln D_{ij}$	−1.48[a]	−1.44[a]	−1.44[a]	−1.45[a]	−1.46[a]	−1.44[a]	−1.45[a]	−1.46[a]	−1.48[a]	−1.45[a]
	(−16.17)	(−16.23)	(−16.22)	(−16.59)	(−16.37)	(−16.23)	(−16.25)	(−16.37)	(−16.30)	(−16.57)
home	5.55[a]	3.29[a]	3.01[a]	1.25[a]	3.14[a]	3.01[a]	2.92[a]	–	–	–
	(25.54)	(33.53)	(16.52)	(6.65)	(34.27)	(32.66)	(24.77)			
$home \times tbt_k$	−0.67[a]	–	–	–	–	–	–	–	−0.70[a]	–
	(−12.98)								(−11.31)	
$home \times tbt_k$*	–	−0.60[a]	–	–	–	–	–	–	–	−0.35[a]
		(−5.76)								(−2.97)
$home \times ntb_k$	–	–	0.02	–	–	–	–	–	−0.16	−0.10
			(0.26)						(−1.50)	(−1.05)
$home \times \ln co_k$	–	–	–	−0.45[a]	–	–	–	–	−0.35[a]	−0.42[a]
				(−10.83)					(−7.29)	(−9.51)
$home \times w$	–	–	–	–	−0.60[a]	–	–	2.53[a]	4.97[a]	1.60[a]
					(−4.11)			(16.36)	(11.39)	(5.26)
$home \times r$	–	–	–	–	–	0.24[c]	–	3.25[a]	4.65[a]	1.64[a]
						(1.75)		(22.40)	(10.93)	(5.36)
$home \times n$	–	–	–	–	–	–	0.19[c]	3.11[a]	4.38[a]	1.72[a]
							(1.68)	(32.57)	(11.52)	(6.37)
N	3185	3822	3822	3822	3822	3822	3822	3822	3185	3822
pseudo-R^2	0.43	0.43	0.43	0.44	0.43	0.43	0.43	0.43	0.44	0.44

Notes: Tobit estimations, sample mean elasticities. Industry-specific distance interaction terms (meat is the excluded industry), and industry-specific origin and destination fixed-effects are included (not reported); *t*-values are reported in parentheses; [a, b, c] denote significance at 1%, 5% and 10% levels, respectively. The probabilities associated with the hypotheses that *w* and *r* effects, *r* and *n* effects, and *w* and *n* effects, are equal are, respectively, 0.00, 0.31 and 0.00 in column (8), 0.10, 0.09 and 0.00 in column (9) and 0.86, 0.55 and 0.46 in column (10).

where $\hat{\beta}_{1,k}$ are the 78 industry-specific *home* coefficients obtained from the industry-specific gravity equations reported in Table 2, X denotes the set of explanatory variables, α is a vector of parameters to be estimated and η_k is an error term. In Eq. (4), the dependent variable consists of estimated coefficients with different significance levels, introducing heteroskedasticity. To control for this, we apply weighted-least-squares where the weights are given by the inverse of the standard errors of the *home* coefficients (Head and Mayer, 2000).

The results are reported in Table 6. They are very similar to our previous findings: industries where TBTs were removed or do not exist (columns (1) and (2)) display smaller border effects; non-tariff barriers are not significant (column (3)); the spatial agglomeration of firms is associated with larger border effects (column (4)); in column (5), where the constant term is replaced by three dummies specific to Rauch's (1999) industry types, the coefficients on r-type and n-type industries are not significantly different but are significantly larger than the one for w-type industries, providing some evidence that product-specific information costs matter.

When all factors are taken together in a single regression (with the tbt_k variable), it can be seen, from column (6), that the significance and signs of the coefficients are generally preserved (the sample is restricted to those industries affected by TBTs, i.e. $N = 65$). Note that the coefficient on tbt_k^* is insignificant (column (7)).

We also regress the industry-specific *home* coefficients, obtained with Wei and Leamer distances, on the various variables. Given that the ranking of *home* coefficients across industries was not much affected by the use of different distance measures, we expect similar conclusions to hold. The results are reported in Tables 7 and 8. The economic interpretation of the estimated coefficients is indeed similar to that in Table 6, but with a few exceptions. In Table 8 (Leamer distances), the coefficient on tbt_k^*, in column (2), is not significantly different from zero. In column (6), the coefficients on the three categories of goods distinguished on the basis of information costs are not statistically different from one another. Finally, in column (7), non-tariff barriers become significant (at the 10% level) but display a negative coefficient, so that industries affected by NTBs display smaller border effects. This is however contrary to what could be expected à priori, so we remain skeptical about this result.

Finally, one might be concerned about the degree to which ready-mix concrete is driving the results. Recall that the *home* coefficient for ready-mix concrete, whatever the distance measure used, is nearly four times that of the next largest industry, and so is a clear outlier. As a final form of sensitivity analysis, all regressions were therefore re-estimated when excluding ready-mix concrete from the sample, but the results generally remain similar to those reported here. Those robustness checks are not reported in order to save space (but are available from the author upon request).

Our empirical results, which tend to be robust to the use of alternative measures of distances, to two different econometric approaches and to the exclusion of ready-mix concrete, provide some support for the role of trade costs in explaining border effects. Technical barriers to trade, together with product-specific information costs, matter in explaining border effects across industries, a result which the previous literature has failed to find. It can thus be argued that deeper market integration, through the removal of trade barriers and of TBTs in particular, should allow to decrease border effects.

Table 6
Explaining border effects (dependent variable is $\hat{\beta}_{1,k}$, obtained with own distance measure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
c	3.31[a] (5.85)	1.34[a] (7.68)	1.37[a] (2.85)	−0.06 (−0.13)	–	–	–
tbt_k	−0.58[a] (−4.14)	–	–	–	–	−0.41[a] (−2.85)	–
tbt_k^*	–	−0.52[c] (−1.93)	–	–	–	–	−0.24 (−0.93)
ntb_k	–	–	−0.15 (−0.53)	–	–	−0.32 (−1.18)	−0.34 (−1.39)
$\ln co_k$	–	–	–	−0.30[a] (−2.65)	–	−0.16 (−1.42)	−0.23[b] (−2.07)
w	–	–	–	–	−0.50 (−1.21)	1.44 (1.47)	−0.50 (−0.69)
r	–	–	–	–	1.03[a] (3.76)	2.42[a] (2.63)	0.70 (0.98)
n	–	–	–	–	1.35[a] (9.19)	2.80[a] (3.18)	1.15[c] (1.75)
N	65	78	78	78	78	65	78
adj-R^2	0.20	0.07	0.03	0.11	0.20	0.29	0.24

Notes: Weighted-least-squares estimations; t-values are reported in parentheses; [a, b, c] denote significance at 1%, 5% and 10% levels, respectively. The probabilities associated with the hypotheses that w and r effects, r and n effects and w and n effects, are equal are, respectively, 0.00, 0.30 and 0.00 in column (5), 0.05, 0.24 and 0.00 in column (6), and 0.02 0.14 and 0.00 in column (7).

Table 7
Explaining border effects (dependent variable is $\hat{\beta}_{1,k}$, obtained with Wei's distance measure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
c	3.99[a] (6.76)	1.72[a] (9.46)	1.77[a] (3.50)	0.16 (0.32)	–	–	–
tbt_k	−0.66[a] (−4.50)	–	–	–	–	−0.52[a] (−3.42)	–
tbt_k^*	–	−0.58[b] (−2.04)	–	–	–	–	−0.33 (−1.16)
ntb_k	–	–	−0.17 (−0.58)	–	–	−0.27 (−0.95)	−0.36 (−1.37)
$\ln co_k$	–	–	–	−0.34[a] (−2.82)	–	−0.21[c] (−1.69)	−0.28[b] (−2.38)
w	–	–	–	–	0.02 (0.04)	2.31[b] (2.19)	−0.04 (−0.05)
r	–	–	–	–	1.31[a] (4.23)	2.85[a] (2.95)	0.80 (1.06)
n	–	–	–	–	1.69[a] (10.69)	3.34[a] (3.57)	1.35[c] (1.91)
N	65	78	78	78	78	65	78
adj-R^2	0.22	0.04	0.01	0.09	0.11	0.26	0.18

Notes: Weighted-least-squares estimations; t-values are reported in parentheses; [a, b, c] denote significance at 1%, 5% and 10% levels, respectively. The probabilities associated with the hypotheses that w and r effects, r and n effects and w and n effects, are equal are, respectively, 0.02, 0.27 and 0.00 in column (5), 0.34, 0.16 and 0.05 in column (6), and 0.15, 0.11 and 0.01 in column (7).

Table 8
Explaining border effects (dependent variable is $\hat{\beta}_{1,k}$, obtained with Leamer's distance measure)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
c	4.98[a] (9.51)	2.81[a] (16.71)	3.25[a] (7.06)	1.42[a] (3.26)	–	–	–
tbt_k	−0.61[a] (−4.76)	–	–	–	–	−0.54[a] (−3.99)	–
tbt_k^*	–	−0.37 (−1.44)	–	–	–	–	−0.24 (−0.93)
ntb_k	–	–	−0.35 (−1.36)	–	–	−0.32 (−1.25)	−0.45[c] (−1.78)
$\ln co_k$	–	–	–	−0.31[a] (−2.95)	–	−0.20[c] (−1.86)	−0.27[b] (−2.51)
w	–	–	–	–	1.71[a] (3.71)	4.22[a] (4.43)	1.74[b] (2.29)
r	–	–	–	–	2.66[a] (9.13)	4.42[a] (5.02)	2.29[a] (3.17)
n	–	–	–	–	2.75[a] (18.65)	4.55[a] (5.38)	2.55[a] (3.82)
N	65	78	78	78	78	65	78
adj-R^2	0.19	0.05	0.05	0.12	0.07	0.21	0.16

Notes: Weighted-least-squares estimations; t-values are reported in parentheses; [a, b, c] denote significance at 1%, 5% and 10% levels, respectively. The probabilities associated with the hypotheses that w and r effects, r and n effects and w and n effects, are equal are, respectively, 0.08, 0.78 and 0.03 in column (5), 0.69, 0.66 and 0.46 in column (6), and 0.31, 0.40 and 0.09 in column (7).

However, the endogenous location responses by firms are also shown to contribute to the overall effect. This in turn implies that, despite further market integration, it seems unlikely that border effects will completely disappear.

6. Concluding remarks

Borders reduce trade. This is the conclusion of a series of papers, including ours, that examine the trade-reducing effects of borders. The purpose of our study consists of examining and explaining the magnitude of border effects for a set of European countries and manufacturing industries. First of all, this paper emphasizes that controlling for relative prices significantly decreases the size of border effects. The way distances are measured also matters for the size of the effect.

Secondly, our work aims at explaining border effects across industries, and in particular at challenging the trade barriers explanation of border effects. Technical barriers to trade, together with product-specific information costs, are shown to increase border effects. Non-tariff barriers are not significant. Our analysis further suggests that the elasticity of substitution among varieties is not driving the cross-industry variance in border effects. Finally, cross-border transaction costs may lead some firms to agglomerate, so that industries not tied to a specific location display larger border effects. This can be taken as an indication that border effects are, to some extent, endogenous.

In the context of the European Union's integration process, what can be said about the evolution of border effects? With the 1992 Single Market Programme, the abolition of border controls on intra-EU trade, as well as the harmonization or mutual recognition of standards and other regulations, were intended to increase intra-EU competition and hence intra-EU trade. Accordingly, and as suggested by our results relating to TBTs, further market integration should reduce, to a certain extent, the magnitude of border effects. Monetary Union should also stimulate intra-EU trade and reduce border effects by increasing transparency between markets. Border effects can therefore be expected to decrease in the future, but given that they also reflect the optimal location choices of producers, it seems unlikely that they will fully disappear.

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Appendix A. The measurement of intra-national and international distances

First, in order to distinguish the regions of a country in terms of economic activity, the share s_m of each region m[19] in the country’s GDP is calculated for 1996,

$$s_m = \left(\frac{GDP_m}{GDP}\right)$$

International distances

Using the latitudes and longitudes of the main city in each region, all bilateral distances between the cities of both countries are calculated by the ‘great circle distance’ formula which is based on the assumption that the earth is a true sphere (Fitzpatrick and Modlin, 1986). All distances are then each weighted by the GDP share of both regions in the total, giving more weight to regions with the strongest economic activity (and which should be more involved in trade).

[19] The data are provided at the NUTS-2 level which is the Eurostat nomenclature of statistical territorial units, subdividing the 15 EU countries into 206 NUTS-2 regions.

Table 9
International and intra-national distances

	FR	GER	IT	UK	SP	FI	PO	BELU	NL	IRL	DK	GR	SE	AT
FR	**415**													
GER	724	**342**												
IT	900	909	**441**											
UK	739	869	1487	**271**										
SP	911	1517	1293	1347	**452**									
FI	2170	1464	2247	1841	2987	**362**								
PO	1286	1900	1769	1509	598	3123	**205**							
BELU	485	430	1041	521	1264	1730	1570	**113**						
NL	622	400	1131	536	1420	1544	1710	186	**114**					
IRL	1026	1239	1853	457	1397	2047	1370	909	926	**139**				
DK	1128	560	1432	902	1945	1084	2297	691	539	1255	**148**			
GR	1919	1730	1094	2482	2247	2605	2756	1978	2023	2856	2117	**308**		
SE	1496	890	1754	1235	2315	790	2709	1092	923	1561	427	2330	**468**	
AT	931	549	619	1319	1588	1763	2061	807	836	1703	967	1219	1270	**228**
	100	100	174	85	263	100	126	na	59	na	165	na	104	91
Wei (1996)														
Leamer (1997)	418	337	310	279	401	328	171	103	115	150	117	205	362	163
Head and Mayer (2000)	397	294	385	230	418	na	161	66	95	138	109	232	na	na

Notes: All distances in kilometres. Abbreviations for the countries are as follows: FR, France; GER, Germany; IT, Italy; SP, Spain; FI, Finland; PO, Portugal; BELU, Belgium–Luxemburg; NL, Netherlands; IRL, Ireland; DK, Denmark; GR, Greece; SE, Sweden; AT, Austria; na, not available.

Domestic distances

In each country, distances between the main city of each region are first obtained by applying the 'great circle distance' formula (as in the case of international distances). For each country, intra-national distances are then given by the average of these distances between the regions of the country, each weighted by the GDP share of both regions in the total, so that the role of the most economically relevant regions in a country is again emphasized.

Note that this method permits the calculation of both intra- and international distances using the same methodology. This is quite similar to Head and Mayer (2000) except that they use the share of two-digit industry level employment for origin weights and GDP for destination weights.

Table 9 reports, for each EU member state, our international and intra-national distances (kms) as well as the internal distances computed by the methods of Wei (1996), Leamer (1997) and Head and Mayer (2000). One can first note that Wei's (1996) domestic distances are, in all cases, much smaller than those obtained by Leamer (1997), Head and Mayer (2000) and by us. Our results are similar to those of Leamer (1997), but our intra distance is larger in the case of Italy, perhaps reflecting the particular length of that country. Further, note that our intra-national distances are larger than those of Head and Mayer (2000), but this observation also holds for our international distances. However, the estimation of border effects depends first of all on the **relative** magnitudes of external and internal distances. Hence, it is very important to obtain measures of internal distances that preserve the true ratio between intra- and international distances. So despite our larger magnitudes for both intra- and international distances, the correlation between our distances (both inter and intra) with those of Head and Mayer (2000) is equal to 0.985.

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