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Distance deterrence, trade barriers and accessibility. An analysis of market potential in the European Union

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The interest in disentangling the role of borders in international trade is growing even within virtually borderless areas like the European Union. While there are a variety of research studies measuring how borders affect trade, there is little insight into the impact of borders on the potential accessibility to markets. The aim of this paper is twofold. First we provide a coherent calibration of the impedance parameters affecting trade (border effect based on best official data available and with a sound estimation of distance and the distance decay parameter with the use of network-based measurements). The second objective is to ascertain to what extent the market potential of different countries is hampered by the border effect. The analysis reveals that calibrating distance decay and considering border effects provides more realistic results. These results evidence that peripheral areas are more sensitive to the estimation of the distance decay parameter, whilst the main metropolitan regions are less affected by both distance decay and border effects. Finally, we present the decomposed market potential in a spillover-like matrix showing those countries that have a diversified set of contributors to their market potential and those where the number of contributors is limited.

Keywords: *accessibility, border effect, European Union, market potential, spatial spillovers.*

1. Introduction

Accessibility is regarded as a key aspect of regional economic development. Regions and countries with better access to the locations of input materials and markets tend to be more productive, more competitive and hence more successful than more remote and isolated areas (Linneker, 1997). Equitable accessibility to markets is considered a crucial factor for the success of the social and economic integration of the European Union and to achieve harmonious economic development. The European Spatial Development Perspective considers that having good accessibility improves not only the competitive position of European regions but also the competitiveness of Europe as a whole (European Commission, 1999). Not surprisingly, accessibility within the European Union has been a popular research topic for many years (some reviews can be found in Bruinsma and Rietveld, 1998; Wegener et al., 2000; Wegener, 2001;

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Spiekermann and Neubauer, 2002). The European Observation Network, Territorial Development and Cohesion (ESPON) has shown great interest in analysing accessibility within the European Union in order to support policy makers engaged with regional competitiveness and territorial cohesion in their considerations in the policy process (ESPON, 2005, 2011, 2007).

Improved infrastructures entail a reduction in transport costs and an increase in accessibility, which can raise regional competitiveness and produce economies of specialisation and scale (Forslund and Johnson, 1995). Consequently, accessibility indicators have been used as a planning tool to measure the potential economic impacts of the construction of new infrastructures (see, for example, López, et al., 2008 or Stepniak and Rosik, 2013). Due to the network effect (Lair et al., 2003), the impact of improving one or several links may affect distant regions, or even regions located in different countries, thus generating what is known as the spillover effect (Pereira and Roca-Sagalés, 2003; López et al., 2009; Gutiérrez, 2010; Condeço-Melhorado et al., 2014). In reality, these impacts are mitigated by the presence of international borders, which lack of consideration may lead to an overestimation of the impact of a new infrastructure at the international level (Gutiérrez et al. 2011).

Several studies confirm that borders still matter within the European Union acting as trade barriers. It has been verified that averaged over all EU countries, intranational trade is about ten times as high as international trade with an EU partner country of similar size and distance other things being equal (Nitsch, 2000). Although it is true that trade tends to decrease progressively with distance (distance decay), accessibility studies should also consider that borders still are barriers that represent abrupt changes in international trade flows. Therefore, in addition to the spatial impedance (distance, travel time or generalized transport costs for accessing markets), political, cultural or linguistic barriers between countries should also be included in accessibility models. However, most studies at the European level ignore the role of borders and other trade barriers when measuring the accessibility of regions and countries, thus leading to unrealistic results. An exception is the paper of Head and Mayer (2004), who calculate market potential with trade barriers in the European Union. Still, they do not analyze their results but simply use them as an input to study the location of Japanese investment. Gutierrez et al. (2011) use the market potential indicator to estimate the spatial spillovers produced by a new motorway in Eastern Europe using a border effect value calibrated in a previous paper. Finally, Salas- Olmedo et al. (in press) focus more on investigating the effect of different distance metrics in the estimation of the border effect than on including its results in accessibility models. In sum, there are very few papers in the accessibility literature that consider trade barriers and they are not properly focused on analyzing their effects on accessibility.

The main aim of this paper is to develop a methodology for including the effect of trade barriers in the calculation of the market potential. This methodology allows reaching more realistic results when measuring accessibility patterns in an international framework and when estimating the accessibility impacts of international projects. We integrate two previously independent lines of research: on the one hand, the role of international borders and other barriers on trade, and on the other hand the calculation of accessibility to markets. For this, we introduce the border effect in the analysis of the market potential within the European Union (EU) after calibrating distance decay, border effect and other trade barriers, such us adjacency, language and currency. This is done with the use of gravity equations. In a second step, both the distance decay and the trade barrier parameters that are found to be statistically significant are introduced in subsequent market potential specifications in order to study the impact of these parameters on accessibility calculations at different spatial scales (national and regional). In addition, the market potential composition of each country is analyzed, identifying its self-potential and the market potential received from each of the other countries.

The paper is organized as follows: Following this introduction, the next section contains an overview of how previous literature tackled the estimation of the market potential and the border effect. Section 3 shows the methods and data used for estimating market potential and trade barriers in the European Union. Section 4 contains the results of our research and Section 5 presents the final remarks of the paper.

2. Market potential and border effects

2.1 Accessibility, market potential and spatial spillovers

There has been a growing interest in measuring and studying accessibility since the seminal works of Harris (1954) and Hansen (1959) defining accessibility as the "potential of opportunities for interaction". The vast number of accessibility indicators reflects the intense research activity in the field as well as the broad implications of accessibility for the economy, society and the environment. Bruinsma and Rietveld (1998) provide an in-depth revision of accessibility indicators in the European framework whilst Geurs and van Wee (2004) establish a typology of accessibility indicators according to the components that they analyze.

From the economic perspective, there was an early interest in studying the accessibility of countries and regions to markets within the European Union. Clark et al. (1969) raised awareness to the different impact of border removal on the accessibility of industry to markets in peripheral and central areas, and in recent decades a number of studies have investigated accessibility disparities within the European Union, for example, Keeble et al. (1988), Lutter et al. (1992), Gutiérrez and Urbano (1996), Bruinsma and Rietveld (1998), Spiekermann and Neubauer (2002). In addition, ESPON has been publishing accessibility reports in recent years, concluding that accessibility seen from a European level might not reflect the same patterns as accessibility observed from a national or regional perspective. Moreover, accessibility is recognised today as an important factor in the development of territories, regions and cities.

Most European accessibility studies (see, for example, Spence and Linneker 1994; Geertman and Ritsema 1995; Bruinsma and Rietveld 1998; Gutiérrez, 2001; Lopez, 2005; Yoshida and Deichmann, 2009) use the market potential indicator (Harris, 1954). The underlying assumption in the use of this indicator is that regions with better access to markets have a higher probability of being economically successful (Wegener and Bökemann, 1998). According to this model, the level of opportunities between places of origin *i* and destination *j* is positively related to the mass of destination *j* and inversely proportional to the distance or travel time between the two places. Different distance decay functions can be used for modelling market potential. The exponential function has been widely used in interaction models and when measuring potential accessibility at the regional level (ESPON, 2007, 2011). However, Fotheringham and O´Kelly (1989) point out that the exponential model is scale dependent, which challenges the comparison between accessibility studies from different data sources. In the case of long distances, the potential function is considered to be more appropriate since the tail is longer than the exponential function. Reggiani et al. (2011) and Östh et al. (2013) concluded that from the spatial econometrics and the network analysis viewpoint the potential function provides a better fit to interaction models, with and without restrictions, and to mobility patterns. Considering the European-wide geographic scale and coverage of this research, this study uses the negative potential function. Its classical mathematical expression is as follows:

$$P_i = \sum \frac{m_j}{t_{ij}^{\alpha}} \qquad (1)$$

Where P_i is the market (economic) potential of node *i*, m_j is the mass of the destination *j*, t_{ij} is the distance (in our case, travel time) by the shortest path in the network between origin *i* and destination *j*, and *a* is a parameter that reflects the effect of the distance. The mass of the destination represents the number of interaction opportunities, so it can be modelled with different variables. When estimating accessibility to markets, as is the case with this study, an economic measure such as GDP is more suitable than the demographic measures used by others (ESPON, 2007; O'Kelly and Horner, 2003).

The *a* parameter is critical in market potential analyses. Although distance has always a negative effect on spatial interactions, this effect may be greater or lesser, and this variability can be represented on the model by the distance exponent (Haynes and Fotheringham, 1984). High values of this exponent imply strong resistance to movement between one place and another, with more relations produced over short distances. Conversely, low values mean lower distance deterrence and, as a result, although relations over short distances continue to be the most important, those that are established over long distances are gaining significance. While some European accessibility studies choose the value 1 (Keeble et al., 1988; Bruinsma and Rietveld, 1998; Holl, 2007, 2011; Lopez, 2005; Tagai et al., 2008), access to origin-destination matrices is growing and there are a number of accessibility papers that calibrate the distance decay parameter using gravity models (see, for example, Reggiani and Bucci, 2008; Reggiani et al., 2011; Condeço-Melhorado et al., 2013) in order to obtain more realistic results. However, international flows are also affected by borders, since both goods trade and passenger trips experience a sharp fall at international borders (McCallum, 1995). Previous studies (see next subsection) indicate that borders still affect the flow of goods between European countries. Yet, most accessibility studies ignore the influence of borders on accessibility to markets in an international framework.

2.2 Barriers to trade

The study of the home bias, i.e. the excessive proportion of domestic versus international trade due to the effect of borders, was pioneered by McCallum (1995), who studied the trade patterns between the US and Canada. McCallum (1995) applied a global gravity model (formula 2) in which exports from a region to any other were a function of the mass at origin and at destination, and the distance between them. In order to account for the home bias, he introduced a dummy variable whose antilogarithm expresses the number of times that a region trades more with another region in the same country than with a region at the same distance located in another country, other things being equal:

$$\ln X_{ij} = \beta_0 + \beta_1 home + \beta_2 \ln Y_i + \beta_3 \ln Y_j + \beta_4 \ln D_{ij} + \varepsilon_{ij} \quad (2)$$

where trade between country i and country j (X_{ij}) is a function of the production of the country of origin, expressed in GDP (Y_i), the attractiveness of the destination country, expressed in GDP too (Y_j), the distance between both countries (D_{ij}), a dummy variable to account for foreign trade (*home,* equal to one when country of origin and destination are the same and zero otherwise), and an error term ε_{ij}.

McCallum's results were criticized for the extremely high home bias value obtained (he estimated an the overall effect of borders in 22 times between the US-Canadian border). Yet, his gravity model is the base of extensive literature on the issue. Research on European countries evidences a wide range of values. For example, Wei (1996), Nitsch (2000), Head and Mayer (2000) or Chen (2004) found border effect values ranging between 6 and 20. Results seem to be very sensitive to the set of countries introduced in the model as well as to the sector analysed.

In addition, there is a growing interest in understanding the influence of distance measurements on the estimation of the border effect. In a first stage, the main contributions relate to the sensitivity of the gravity model to different estimations of intra-national and international distances still operating with extremely simplified measurements like Euclidean or great circle distances (Head and Mayer, 2002; Clark and van Wincoop, 2001; Nitsch, 2000; Wei, 1996; Chen, 2004). Later, some authors made use of alternative distance measurements, like Road Atlas (Wolf, 1997, 2000) or reported distances in transport surveys (Hillberry and Hummels 2003). Whilst transport surveys rarely cover international frameworks, nowadays, there is growing access to seamless road and ferry networks across Europe, which allows for more accurate calculations of shortest distance and travel time routes. Salas-Olmedo et al. (in press) replicated Chen's work with an updated dataset using four different distance measurements (Euclidean distance, network distance, travel time, and generalized transport costs), and concluded that simpler distance measures underestimate the border effect.

McCallum's seminal model has been modified with additional variables indented to capture other barriers to trade that are independent from the border effect. In European studies, most authors were interested in controlling for adjacency, common language and remoteness (Wei, 1996; Nitsch, 2000; Head and Mayer, 2002). Adjacency (i.e. sharing a common border) and common language are straight-forward indicators and are easily computable as dummy variables. On the contrary, remoteness (i.e. distance to all bilateral partners) is not exempt of critics due its weak theoretical foundation (Anderson and van Wincoop 2001). Not surprisingly, the latter is often not considered at all (Head and Mayer, 2000; Clark and van Wincoop 2001; Chen, 2004; Gil-Pareja et al. 2005).

3. Methodology and data

3.1 Source of data and travel time calculation

A full origin-destination matrix with bilateral trade between pairs of countries as well as internal (i.e. domestic) trade is required in order to obtain the dependent variable of the gravity model (formula 2). Traditionally, data of international trade has been extracted from origin-destination trade matrices available in Eurostat's Comext database, the UN trade database or the OECD. The main drawback of these databases is the lack of information on domestic trade (i.e. the diagonal of the matrix), which in turn needs to be estimated. This estimation is typically made by subtracting the sum of all exports from the national production (Wei 1996, Nitsch 2000, Head, Mayer 2000, Chen 2004). Because the data on exports and the value of the national production comes from different data sources, the result of this operation sometimes results in unreliable figures. In addition, it definitively stresses the Rotterdam effect[4]. This means that the diagonal of the matrix is particularly inaccurate for countries whose exports include a large proportion of imported products (as opposed to those countries exporting mainly national production).

The fact that these origin-destination matrices are used precisely to calibrate the home bias (or the border effect, note the difference is in the perspective) makes it essential to obtain accurate values of domestic trade. In this research we use the World Input/Output Database (Timmer et al., 2012) in order to overcome the above-mentioned difficulties to estimate domestic trade. In addition to the traditional national input/output tables, the WIOD comprises an international input/output table detailing flows of different commodities to intermediate sectors and final demand consumers. Unlike previous studies, we have been able to obtain a fully complete and consistent matrix of internal and bilateral trade between countries, thus removing the inaccuracies of estimated domestic trade values. In particular, a country-level origin-destination matrix of the value in Euros of agricultural, mining and manufactured goods in 2011 for the EU-27 was built from this database. While this dataset has been used in some studies related to international trade (Foster-McGregor et al., 2013), to the best of our knowledge our research pioneers the calibration of the effects of borders on international trade with the use of input/output tables, thus overcoming the main drawback of the estimations in previous studies.

The GDP of the country of origin (Yi) and of the destination country (Yj) were taken from EUROSTAT, referring to the year 2011. Special care should be taken when computing origin-destination distances since the border effect is sensitive to both the metric and the procedure for the calculation of intra-national and international distances. Regarding the former, in this study we decided to use travel times because, showing similar results to generalized transport costs (Salas-Olmedo et al., in press), they are easier to compute. This makes the results easier to compare with previous or future research. Travel time was computed for year 2012 based on the Database of European roads 1957-2012 (Stelder, 2013), and common speeds for each road tyoe according with general truck allowances. Similarly to Chen (2004, p. 117), we applied a common

[4] European Commission (2006) recognizes that Eurostat figures are affected by the so-called Rotterdam effect. For further explanations on its origin and consequences see also ONS (2009).

methodology to compute intra-national and international distances in a homogeneous way based on an aggregation of distances between regions. First, the internal distance of NUTs3 regions in kilometres was computed as in formula (3):

$$D_{ii} = \frac{1}{2}\sqrt{\frac{S_i}{\pi}} \tag{3}$$

where D_{ii} is the internal distance (in km) of region i, and S_i is its surface (in square kilometres).

Since some NUTs3 are urban in nature and others are rural, a congestion effect should be considered within zones. Therefore, the internal speed of each NUTs3 region was estimated according to its population density (as a proxy of congestion). The region with the lowest population density was assigned a speed of 80 km per hour whereas the region with the highest value was assigned a speed of 20 km per hour (Gutiérrez et al., 2011). Finally, the internal travel time within each zone was calculated using the estimated internal distances and speeds. Then, region-to-region travel time (at the NUTs3 level) was computed using a commercial GIS (ArcGIS 10.1) that includes specific network simulation routines for the calculation of minimum paths through the network.

Finally, formulas 4 and 5 was used to calculate the travel time between the exporter country i and the importer country j as the average of the travel time between all NUTs3 regions in the country of origin i and all NUTs3 regions in the destination country weighted by the population size at origin i and destination j:

$$T_{ij} = \frac{\Sigma\left(T_{m_i m_j} \times S_{m_i} \times S_{m_j}\right)}{\Sigma\left(S_{m_i} \times S_{m_j}\right)} \tag{4}$$

$$S_m = \left(\frac{Pop_m}{Pop}\right) \tag{5}$$

where T_{ij} is the travel time between county i and country j, T_{mimj} is the travel time between region m in country i and region m in country j, Pop_m is the population of region m and Pop is the total population. The weighting factor used was population instead of GDP since EUROSTAT does not provide GDP data for all current NUTS 3 regions.

This methodology has the advantage of providing a homogeneous metric for internal and international distances. However, it is not suitable for very small countries which have only one or two NUT 3 regions. For this reason, and in order to keep a homogeneous distance measurement, Cyprus, Malta and Luxembourg were removed from the analysis.

3.2 Methodology

According to its classical formulation, the market potential of each country is positively related to the mass of the destination and inversely proportional to the distance between the two countries. Results from research reported in previous sections evidenced that market potential is also affected by European borders as an element of friction, thus reducing trade. In addition, countries trade less with non-adjacent countries than with adjacent ones, other things being equal. Our contribution in this regard consists in introducing these variables in the traditional market potential specification as additional elements in order to express market potential in a more realistic way. The calibration of the distance decay, border effect and non-adjacency coefficients was made through the gravity model (formula 6):

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln D_{ij} + \beta_4 border + \beta_5 nonadjacency + \varepsilon_{ij} \tag{6}$$

where β_4 is the coefficient of the border variable, β_5 is the coefficient of the non-adjacency variable, $\beta_3$is the distance decay parameter, and the other terms are already known (see formula 2). The antilog of β_4 indicates the number of times that a country trades less with another country than within its own boundaries, thus it can be interpreted as a reduction factor of the GDP at destination for international relations. Similarly, the antilog of β_5 expresses the number of times that a country trades less with non-adjacent countries than with adjacent ones. Formula 7 shows the specification of the market potential indicator introducing the effect of borders and non-adjacency in international relationships.

$$P_i = \sum \frac{Y_j/(e^{\beta_4} \cdot e^{\beta_5})}{t_{ij}^{\beta_3}} \tag{7}$$

where P_i is the market potential of country or region i, Y_j is the GDP of destination country or region j, t is the travel time between i and j, β_3 is the distance decay parameter, β_4 is the coefficient of the border variable, and β_5 is the coefficient of the non-adjacency variable. This function indicates that opportunities for interaction decrease with distance in a discontinuous way (due to the border and non-adjacency effects) and not according to a continuous function as the classical specification of the market potential model suggests (Figure 1).

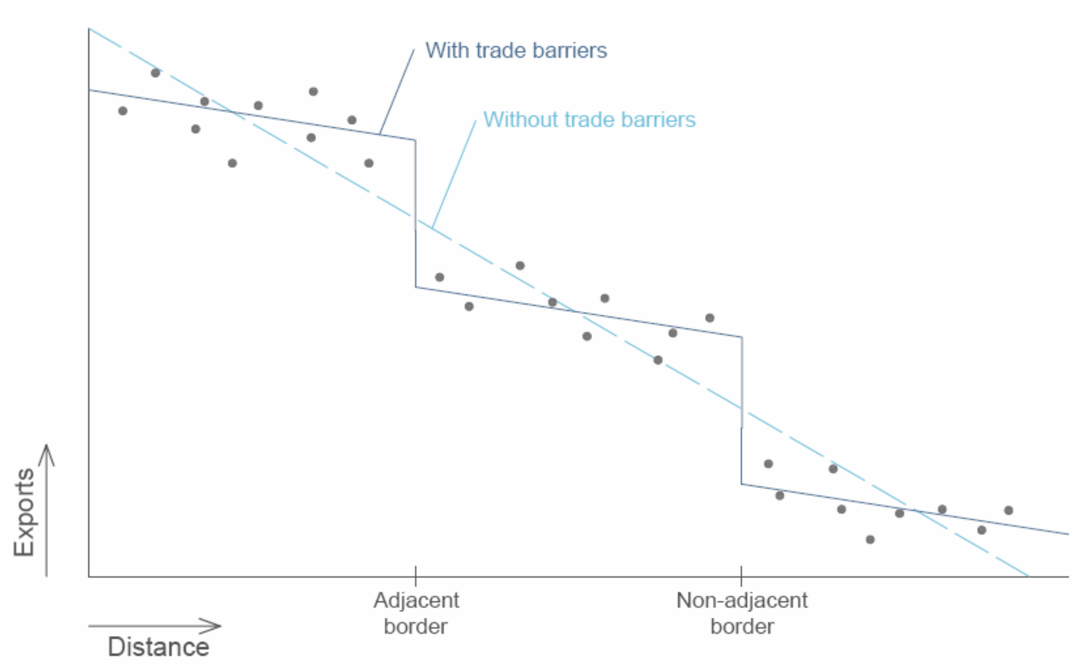


Figure 1. Adjusting distance and exports with and without trade barriers (others things being equal)

Previous studies focussed on the estimation of the border effect from the home bias viewpoint, i.e., they were interested in knowing how much a region trades more within its country than with foreign regions. In contrast, our interest here is to ascertain the border effect, i.e., to what extent trade between foreign areas decreases due to the existence of an international border between them, other things being equal. For this reason, our dummy variable *border* was built the opposite way, i.e. using a value of 1 when the destination country is different from the country of origin, and 0 otherwise. Similarly, our dummy variable non-adjacency is 0 when two countries share a border and 1 otherwise.

We built some additional dummy variables in order to test the role of language and currency as barriers to trade. The variable reflecting the existence of a currency barrier is 0 for countries in the Eurozone and 1 otherwise. In the case of language, we built two dummy variables in order to capture two levels of language difference based on the official languages of the European Union, as stipulated in the latest amendment of *Regulation No 1 determining the languages to be used by the European Economic Community of 1958*. The first variable (language strict) accounts for 0 when two countries share a language that is official in all their territory and 1 otherwise. Then, we constructed a second variable (language lax) in which for each pair of countries, we recorded 0 when a language is official in at least one region of each country, and 1 otherwise. These variables can be included in equations 6 and 7 analogously to the border effect and non-adjacency variables.

The market potential values obtained are presented at the country level and at the regional level in order to explain how results are affected by the calibrated coefficients of distance and trade barriers. In addition, a full market potential breakdown is performed considering each of the countries involved. This decomposition is presented in the form of a spatial spillover matrix (Gutiérrez et al., 2010, p. 141)), showing the amount of potential a country receives from each of the other countries. Finally, we calculated the coefficient of variation of each column of the spillover matrix, thus showing the degree of concentration of the spillovers received by each country, and the correlation coefficient between the matrices of market potential and exports to check the degree of similarity between both matrices.

4. Results

4.1 Analysing and calibrating distance deterrence and barriers to trade

Bivariate correlations among the selected variables were calculated in order to explore the influence of every single candidate predictor on trade and the potential existence of multi-collinearity issues. The dependent variable, i.e. the exports from country *i* to country *j*, correlates with the expected signs with all candidate predictors: positively with GDP both at origin and at destination and negatively with distance and trade barriers. The first column in Table 1 evidences that, as expected, distance (travel time in minutes) between origin and destination, the GDP of the origin/destination country and the dummy *border* are largely correlated with exports. Examining the full matrix reveals that mass at origin and destination show low correlation coefficients with most of the other candidate independent variables. All the correlations between the candidate predictors are below the danger level of 0.7 (Clark, Hosking 1986), except for the relationship between the two language variables, but these are not intended to be in the model at the same time.

Table 1. Pearson's correlation matrix between variables

	$Exp._{ij}$	GDP_i	GDP_j	D_{ij}	Border	Non-A.	L.B. (s)	L. B.(l)	Curr.B.
$Exports_{ij}$	1								
GDP_i	0.564**	1							
GDP_j	0.511**	0.000	1						
D_{ij}	-0.546**	0.002	0.002	1					
Border	-0.395**	0.000	0.000	0.542**	1				
Non-Adjacency	-0.308**	-0.064	-0.064	0.444**	-0.072	1			
Lang. barrier (s)	-0.203**	-0.071	-0.071	0.269**	-0.037	0.453**	1		
Lang. barrier (l)	-0.260**	-0.106*	-0.106*	0.315**	-0.052	0.626**	0.717**	1	
Currency barrier	-0.149**	-0.150**	-0.150**	0.054	0.107*	0.058	0.082	0.100*	1

** Significant at the 0.01 level (bilateral).
* Significant at the 0.05 level (bilateral).
Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

These candidate predictors were subsequently integrated in McCallum's original model as in formula 2. Then, each independent variable that is significant remains in subsequent models until all significant variables are inside. For comparative purposes the gravity model without considering the border effect has also been adjusted (Model 0). Table 2 the shows results of

Ordinary Least Squares (OLS) models (i.e. all flows between the 24 countries are considered). All models show high R^2 values and a high overall significance (F-test). All tolerance values are below 2.2, thus multi-collinearity is not an issue. In models 0, I and model II all independent variables are significant at the 0.05 level and have the expected signs. In contrast, not sharing a common language (models III and IV) is not significant, and not sharing a common currency (i.e. the Euro) (model V) is not highly significant and surprisingly has the opposite sign to the one expected. Therefore, and considering the R^2, F and AICc values, model II was selected as the best gravity model. In fact this model has the same predictors as those included in models of previous work on border effects (e.g., Chen, 2004). The values obtained for the distance-decay parameter (1.676) and for the border and non-adjacency effects (6.931 and 1.575, i.e. the antilog of -1.936 and -0.454, respectively) are consistent with results obtained in previous research. A look at the models evidences that the introduction of additional trade barriers as dummies leads to a reduction in the value of the distance decay parameter and to an increase in the border effect value. Comparing model 0 (the commonly used, without considering trade barriers) and model II (considering both border and non-adjacency effects) shows that the first not only get a worse fit in terms of adjusted R^2 and AICc, but also (and more important) leads to a large inflation of the distance-decay parameter (Table 2 and Figure 1).

Table 2. Comparison of gravity models (OLS)

	Model 0			Model I			Model II			Model III			Model IV			Model V		
Variables	β	Sig	VIF	β	Sig	VIF	β	Sig	VIF	β	Sig	VIF	β	Sig	VIF	B	Sig	VIF
Intercept	-11.709	0.000		-12.080	0.000		-12.103	0.000		-12.080	0.000		-12.095	0.000		-12.993	0.000	
GDPi	0.931	0.000	1.000	0.930	0.000	1.000	0.924	0.000	1.007	0.925	0.000	1.009	0.927	0.000	1.015	0.938	0.000	1.029
GDPj	0.844	0.000	1.000	0.844	0.000	1.000	0.837	0.000	1.007	0.838	0.000	1.009	0.841	0.000	1.015	0.851	0.000	1.029
Dij	-2.127	0.000	1.000	-1.836	0.000	1.417	-1.676	0.000	2.135	-1.684	0.000	2.167	-1.688	0.000	2.151	-1.663	0.000	2.138
No Home				-1.623	0.000	1.417	-1.936	0.000	1.718	-1.922	0.000	1.730	-1.914	0.000	1.725	-2.035	0.000	1.740
No Adjacency							-0.454	0.000	1.527	-0.490	0.000	1.703	-0.583	0.089	2.072	-0.488	0.000	1.533
No Lang. Str										-0.173	0.402	1.282						
No Lang. Lax													-0.297	0.089	1.681			
No Currency																0.293	0.000	1.064
Exp No Home				5.069			6.931			6.831			6.831			7.654		
Exp No Adj							1.575			1.632			1.632			1.628		
R2	0.880			0.894			0.896			0.896			0.896			0.899		
Adj R2	0.880			0.893			0.895			0.895			0.895			0.898		
F-Stat	1400	0.000		1199	0.000		982	0.000		818	0.000		822	0.000		847	0.000	
AICc	1405			1339			1328			1327			1327			1312		

Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

4.2 The role of international borders in market potential

Table 3 shows the effect of introducing the different parameters of model II on market potential (formula 7) taking the non-calibrated market potential (i.e. distance decay = 1) as a starting point. The influence of these three parameters in market potential values is very high and decreasing (see average figures at the bottom of the table). More interestingly, the introduction of the different parameters enhances the disparities between countries (coefficient of variation, CV). The calibrated distance decay parameter has a major impact on market potential values, evidencing a reduction of over 97 per cent in all cases. This reduction is even greater in relative terms across the peripheral countries of the EU. The impact of the border effect is more unevenly distributed across the EU. The border effect has a greater impact on the market potential of the Baltic and

Eastern countries, whereas countries with large internal markets, like the UK and Germany, and to a lesser extent Belgium, Netherlands, Italy, France and Spain, show a lesser reduction in their market potential after considering the border effect. Introducing non-adjacency in market potential calculations evidences the reproduction of the previous pattern of changes. As expected, the countries with the largest market potential are those with the strongest economies (Germany, UK, and France) and/or a very high GDP density (Belgium and Netherlands). On the opposite side, Baltic and South-Eastern countries have reduced potential access to markets.

Table 3. Market potential values: effects of the introduction of the different parameters of model II (results per country)

	Non calibrated market potential	Calibrated market potential (Model II)			Differences (in %)		
Country	Distance decay = 1	Introducing calibrated distance decay	Introducing calibrated border effect	Introducing calibrated non-adjacency	Loss due to introducing calibrated distance decay	Loss due to border effect	Loss due non-adjacency
Austria	21202846479	324876054	100959483	95500217	-98.468	-68.924	-5.407
Belgium	35553701619	935328483	410422035	400036185	-97.369	-56.120	-2.531
Bulgaria	10758880593	99169850	19612571	15297548	-99.078	-80.223	-22.001
Czech R.	21317266603	329116663	82387306	75745418	-98.456	-74.967	-8.062
Germany	27091491071	478959340	272455649	267231084	-98.232	-43.115	-1.918
Denmark	19944142764	311720016	109904979	102024370	-98.437	-64.742	-7.170
Estonia	14358219566	177025026	31892935	23093610	-98.767	-81.984	-27.590
Spain	16674181510	210886059	85742403	80529603	-98.735	-59.342	-6.080
Finland	12812650994	141736789	38057456	32673505	-98.894	-73.149	-14.147
France	23013281942	345718460	152366530	147290364	-98.498	-55.928	-3.332
Great Britain	26204670426	497856908	286024968	273548725	-98.100	-42.549	-4.362
Greece	13304170822	148042483	43792330	37430861	-98.887	-70.419	-14.526
Hungary	16617389009	216216259	52579430	44315772	-98.699	-75.682	-15.717
Ireland	19009652327	294939471	85022859	78177214	-98.448	-71.173	-8.052
Italy	19498273067	274584913	136199841	130140911	-98.592	-50.398	-4.449
Lithuania	15330146857	186160274	35164416	26778323	-98.786	-81.111	-23.848
Latvia	13889261321	159780778	29472949	21743577	-98.850	-81.554	-26.225
Netherlands	35195911017	905487933	436721127	422419195	-97.427	-51.770	-3.275
Poland	16976715542	217978924	62383258	56718055	-98.716	-71.381	-9.081
Portugal	12719495380	149786338	53032893	48828121	-98.822	-64.594	-7.929
Romania	11132307980	104617681	25125903	20482718	-99.060	-75.983	-18.480
Sweden	14683099596	173958711	49686730	42527697	-98.815	-71.438	-14.408
Slovenia	19504282525	283533201	62494801	53917863	-98.546	-77.959	-13.724
Slovakia	17334534205	232284656	48748644	40796486	-98.660	-79.013	-16.313
Average	18921940551	299990220	112927146	105718643	-98.56	-67.65	-11.61
STD	6516001692	212640347	115521136	113973467	0.42	11.87	7.62
CV	34.4	71	102	108	-0.4	-17.5	-65.6

Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

These market potential losses are closely linked to self-potential values. Countries with less self-potential (see Table 4) experience a greater loss of their total potential due to their greater dependency on international relationships. This is the case with small countries in terms of population and GDP located in Central and Eastern Europe. In contrast, a smaller loss of market potential is evidenced in countries with larger self-potential values. There is a progressive increase in self-potential in relative terms after introducing the selected impedance factors, which leads to more realistic results (Table 4). There is evidence that using a distance decay equal to 1, as it has commonly been used in some previous studies, implies an overestimation of the role of long-distance relationships. In contrast, calibrating the distance decay allows that trade flows fall sharply with distance. Consequently, trade over short distances (most of them being intra-national relationships) are more relevant than what estimations based on distance decay of value

Table 4. Self-potential values: effects of the introduction of the different parameters of model II (results per country)

	Non calibrated market potential	Calibrated market potential (Model II)			Differences (in %)		
Country	Distance decay = 1	Introducing calibrated distance decay	Introducing calibrated border effect	Introducing calibrated non-adjacency	Gain due to Distance Decay	Gain due to border effect	Gain due to non-adjacency
Austria	9.1	19.5	62.6	66.2	114.7	221.8	5.7
Belgium	15.5	34.4	78.4	80.5	121.5	127.9	2.6
Bulgaria	2.0	6.3	31.6	40.5	219.8	405.6	28.2
Czech R.	5.3	12.4	49.5	53.8	132.5	299.5	8.8
Germany	37.5	49.6	87.2	88.9	32.5	75.8	2.0
Denmark	9.8	24.3	69.0	74.4	147.4	183.6	7.7
Estonia	1.2	4.2	23.3	32.1	264.5	455.1	38.1
Spain	19.4	30.7	75.4	80.3	58.4	146.0	6.5
Finland	6.4	14.5	54.1	63.0	127.7	272.4	16.5
France	26.3	34.6	78.6	81.3	31.6	126.9	3.4
Great Britain	34.2	50.3	87.5	91.5	47.2	74.1	4.6
Greece	7.4	17.7	59.9	70.0	139.7	238.1	17.0
Hungary	4.3	11.6	47.5	56.4	171.7	311.2	18.6
Ireland	6.8	16.8	58.4	63.5	145.9	246.9	8.8
Italy	27.3	41.1	82.9	86.7	50.8	101.6	4.7
Lithuania	1.6	5.2	27.6	36.2	217.6	429.4	31.3
Latvia	1.3	4.7	25.5	34.5	258.9	442.1	35.5
Netherlands	20.3	39.5	81.9	84.7	94.4	107.3	3.4
Poland	8.8	16.6	57.9	63.7	87.5	249.4	10.0
Portugal	8.7	24.5	69.2	75.2	181.1	182.4	8.6
Romania	4.5	11.2	46.7	57.2	147.2	316.4	22.7
Sweden	9.1	16.5	57.8	67.6	82.4	250.1	16.8
Slovenia	2.4	8.9	40.4	46.8	266.4	353.7	15.9
Slovakia	2.9	7.7	36.5	43.6	166.1	376.5	19.5
Average	11.3	20.9	57.9	64.1	137.8	249.7	14.0
STD	10.4	13.9	19.7	17.8	69.9	116.9	10.5
CV	91.8	66.2	34.0	27.7	50.7	46.8	74.7

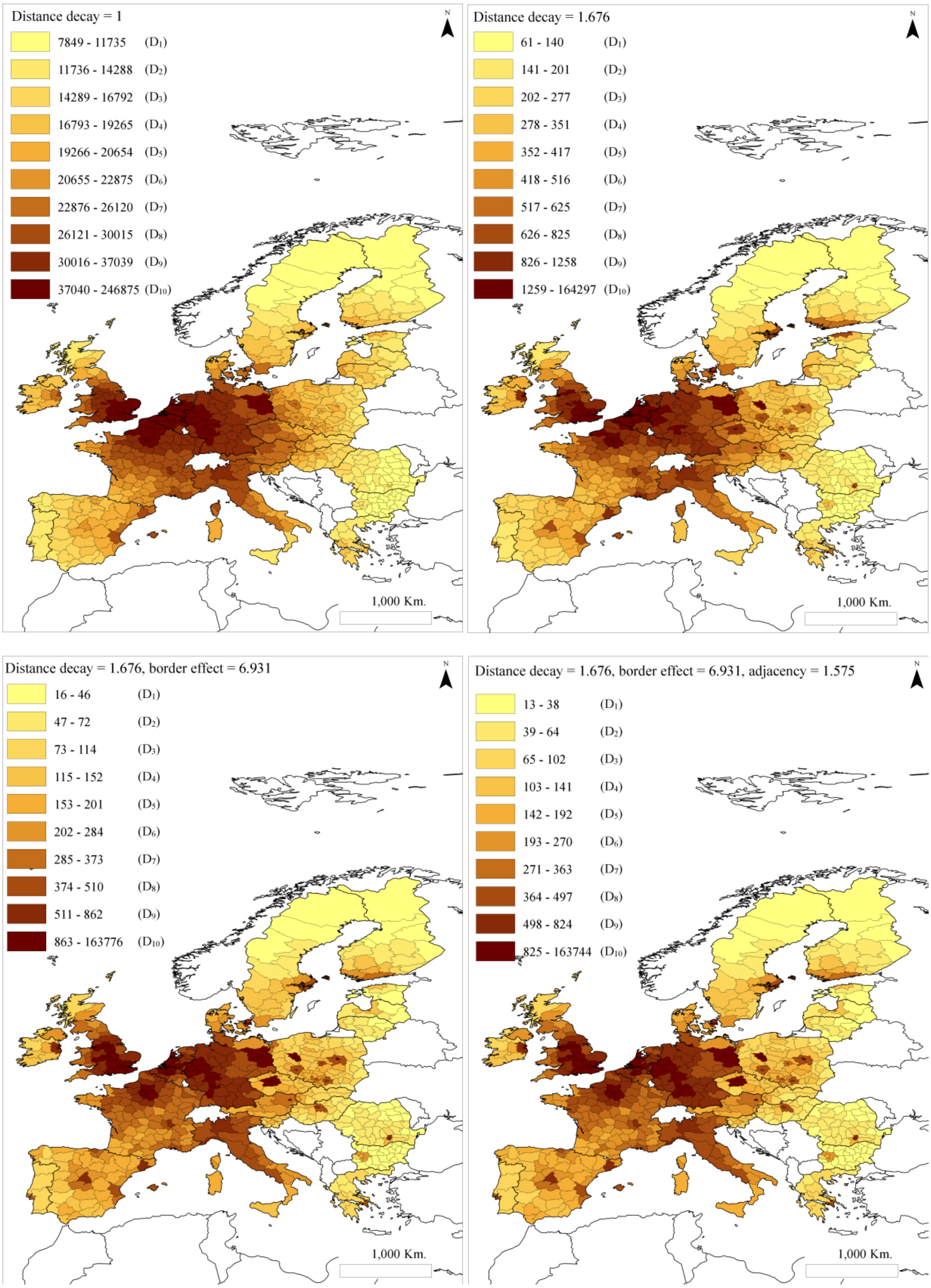
Source: authors' calculation from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

1 reveal. In addition to the fall as a function of distance, potential opportunities fall sharply with the presence of international borders. Therefore, introducing the calibrated border effect in market potential estimations produces a notable decrease in the weight of international relationships, which in turn increases the relative weight of self-potential. The same applies when controlling for non-adjacency. On the other side, the introduction of distance and trade parameters leads to a continuous fall in the variation coefficient values, revealing a reduction in self-potential disparities between countries.

When introducing the different calibrated parameters in the market potential model at the regional level, we face the Modifiable Areal Unit Problem (MAUP) (Kendall, 1939; Griffith, 1992; Bivand, 1998). The MAUP is basically divided in two parts: a) scale dependency (e.g. results at the national level are not equal to the overall results at the regional level), b) the number and layout of internal divisions (zones should be equivalent in form and size). The first part of the problem is not possible to be solved in this research, since there are not reliable trade matrices among EU regions. Regarding the second part, from the different alternatives suggested in ESPON (2006, p.184), we chose the use of a combination of NUTS 2 and NUTS 3 regions[5]. In particular, we updated the NUTS 2/3 level that were used in the EU-LUPA (ESPON, 2012) project with the new NUTS 2010 version. The results we have obtained at the regional level should be interpreted with caution, since the MAUP has been only mitigated. It can be seen, for example, that the small size of some urban regions located in Eastern Europe highlights their accessibility values, yet some general trends can be clearly identified. The maps of market potential at NUTS 2/3 level (Figure 2) evidence a typical concentric spatial pattern at the European level with the area within the Pentagon showing larger values and the peripheral regions obtaining lower values of market potential in the simplest model (distance decay =1). Calibrating the distance decay allows a better differentiation between the market potential of large urban areas and the market potential of less urbanized regions. Considering the effect of borders and non-adjacency between countries reveals the particular disadvantages of some border, peripheral and sparsely populated regions.

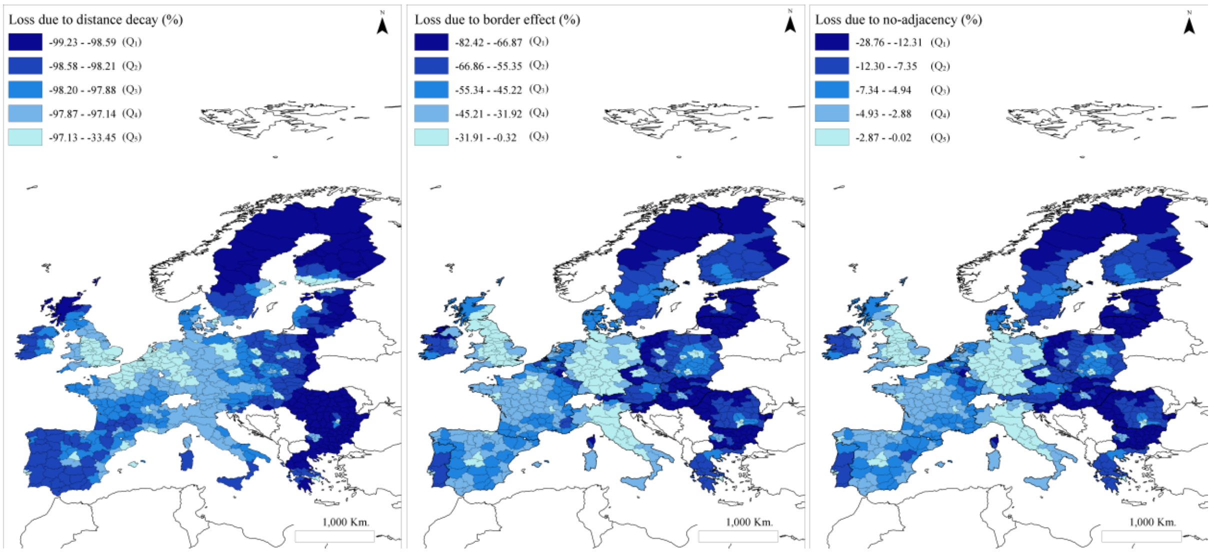
Changes produced by the introduction of the different parameters can be seen in Figure 3, which shows differences in percentage between each subsequent model. Obviously, the greatest loss in market potential is due to the calibration of the distance decay parameter, since it is an exponent to the origin-destination distance. This loss is greater for the peripheral regions (more distant from the main markets), and lower, although always very large, for the main urban regions (because of their high self-potential values). Changes produced by border and non-adjacency effects are particularly intense in less populated regions surrounding the German border, with the German regions and the main urban regions being the least affected by the introduction of these two parameters.

[5] One of these solutions proposed by ESPON is using a grid of 80 x 80 km^2. This size was chosen as "probably the best possible compromise between conservation of spatial differences and elimination of biases introduced by the conversion from territorial units to grid cells" (ESPON, 2006, p. 184). While this grid could be computed from the existing 1 km2 grid with GDP and population data, it is complicated to obtain data at this scale for the target years (i.e. most recent road database and international bilateral trade matrix). Interestingly, the above-mentioned ESPON report indicates that the 80x80km^2 grid is "relatively similar to the distribution obtained with a mixture of NUTS2 & NUTS3 units or to the smoothed map with a gaussian neighbourhood span 50 km". We understand that either the 80x80 km^2 grid or the NUTS 2/3 combination are suitable options to minimise the MAUP at the European scale. From these options, we choose the combination of NUTS2 & NUTS3 units because is the easiest to compute and replicate with current available datasets. In addition, given the focus of the research on the border effect the real limits of international boundaries need to be respected. Finally, we consider that results for regions are politically more relevant than at the grid level.



Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

Figure 2. Market potential values according to different formulations: results per NUTS 2/3 level (in millions of market potential units)



Source: authors' calculations from EUROSTAT, Database of European roads 1957-2012 and GISCO.

Figure 3. Difference in market potential results after introducing subsequent control variables, as a percentage

4.3 Market potential composition: analysing spillover effects

The market potential of each country depends on its internal (self-potential) and international relationships. Tables 5 and 6 present the contribution of each country to the market potential of the others in absolute and relative terms respectively. They may be interpreted as spatial spillover matrices (see Subsection 3.2), thus revealing to what extent each country benefits from the potential opportunities offered by another in terms of market potential. The main diagonal of the matrix shows the self-potential of each country. Each row indicates the amount of market potential that each country provides to the rest of countries, and each column shows the potential that each country receives from the rest of countries. The matrix is highly asymmetric; for example, Germany receives 1.51 million potential units from Austria, whilst Austria only receives 13.13 million from Germany. This reflects the different size of each market. The market potential composition of each country can be identified by following its column. Therefore, for example, the countries that most contribute to the market potential of France are Germany (5.97%), UK (3.10%), Italy (2.95%), Spain (2.14%) Belgium (1.63%), and The Netherlands (1.29%). As a big market, the self-potential value of France is very high (81.31%). As expected, Germany is the country that provides most potential to most of the other countries, due to its high GDP and its central location. However, this is not true in the case of Portugal and Ireland, for example, which are more linked to Spain and the UK, respectively, than to Germany due to their peripheral location and the existence of intermediate opportunities (Spain and the UK, respectively).

The coefficient of variation of each column (excluding the values of the main diagonal) measures the degree of concentration of the potential received from other countries (Table 7). High values indicate that market potential is very dependent on one or a few countries. This is the case of Ireland (highly dependent on the UK) and the Netherlands, Denmark and Czech Republic (closely linked to Germany in terms of market potential). Other countries at a greater distance from large markets show low coefficient of variation values and therefore much less polarized profiles, such as Austria, Bulgaria, Romania, Hungary and the Baltic states.

Table 5. Spillover matrix: contribution of each country to each other's market potential (in millions of market potential units)

	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK	Total
AT	63.2	0.5	0.3	3.8	1.5	0.4	0.3	0.3	0.2	0.4	0.3	0.3	2.8	0.2	1.0	0.3	0.3	0.5	0.74	0.16	0.42	0.29	4.98	2.99	86.32
BE	0.6	321.9	0.2	0.7	3.2	0.8	0.4	0.4	0.3	2.4	2.4	0.2	0.4	1.0	0.5	0.5	0.4	15.1	0.47	0.23	0.19	0.41	0.50	0.41	353.38
BG	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.03	0.02	0.24	0.02	0.05	0.05	7.14
CZ	2.0	0.3	0.1	40.8	1.0	0.3	0.2	0.1	0.2	0.2	0.2	0.1	0.7	0.1	0.2	0.3	0.2	0.3	1.16	0.07	0.19	0.22	0.61	1.83	51.36
DE	13.1	22.6	1.6	16.1	237.6	12.4	3.5	2.3	2.8	8.8	5.9	1.8	4.3	3.4	3.9	4.4	3.5	24.8	8.88	1.40	1.87	3.90	5.61	5.11	399.59
DK	0.3	0.5	0.1	0.5	1.1	75.9	0.8	0.1	0.6	0.2	0.3	0.1	0.3	0.2	0.2	1.2	0.8	0.7	0.74	0.08	0.14	1.19	0.24	0.33	86.75
EE	0.0	0.0	0.0	0.0	0.0	0.1	7.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.04	0.00	0.01	0.11	0.01	0.02	8.35
ES	0.9	1.1	0.6	0.7	0.9	0.5	0.4	64.6	0.3	3.2	0.9	1.0	0.7	0.6	1.9	0.4	0.4	1.0	0.49	4.79	0.54	0.39	1.10	0.64	88.20
FI	0.1	0.2	0.1	0.2	0.2	0.5	1.7	0.1	20.6	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.9	0.2	0.33	0.05	0.09	1.34	0.12	0.18	27.90
FR	2.7	13.0	1.0	2.4	6.7	2.0	1.2	6.0	1.1	119.8	5.2	1.7	1.7	2.9	5.5	1.4	1.2	6.3	1.57	1.97	1.01	1.31	2.49	1.70	191.89
GB	1.7	11.5	0.6	1.9	4.0	2.4	1.3	1.5	1.1	4.6	250.3	0.8	1.2	16.6	1.4	1.5	1.3	12.1	1.55	0.94	0.69	1.44	1.44	1.31	323.39
GR	0.2	0.1	0.8	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.1	26.2	0.3	0.1	0.5	0.1	0.1	0.1	0.14	0.13	0.27	0.08	0.33	0.22	30.70
HU	0.9	0.1	0.2	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	25.0	0.0	0.2	0.1	0.1	0.1	0.26	0.04	0.44	0.09	0.92	1.74	31.43
IE	0.1	0.4	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.2	1.5	0.1	0.1	49.6	0.1	0.1	0.1	0.4	0.10	0.07	0.05	0.10	0.10	0.09	54.09
IT	5.5	2.0	1.6	2.2	2.4	1.1	0.8	2.9	0.7	4.3	1.3	3.5	2.6	0.9	112.9	0.9	0.8	1.7	1.33	1.48	1.43	0.84	7.87	2.10	163.17
LT	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	9.7	0.5	0.0	0.18	0.01	0.02	0.12	0.03	0.05	11.40
LV	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	7.5	0.0	0.05	0.01	0.01	0.09	0.01	0.02	8.74
NL	1.0	24.4	0.3	1.2	5.7	1.6	0.7	0.6	0.6	1.9	4.1	0.3	0.6	1.6	0.7	0.9	0.7	357.7	0.87	0.33	0.31	0.79	0.77	0.69	408.26
PL	0.9	0.5	0.3	2.8	1.3	1.1	0.9	0.2	0.7	0.3	0.3	0.2	1.0	0.2	0.3	2.1	0.9	0.5	36.15	0.12	0.39	0.86	0.64	2.60	55.27
PT	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.8	0.0	0.2	0.1	0.1	0.1	0.1	0.2	0.0	0.0	0.1	0.06	36.72	0.06	0.05	0.11	0.07	39.29
RO	0.2	0.1	0.8	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.6	0.0	0.1	0.1	0.1	0.1	0.14	0.05	11.72	0.07	0.19	0.27	15.27
SE	0.4	0.4	0.2	0.6	0.6	1.9	2.6	0.1	2.7	0.3	0.3	0.1	0.3	0.2	0.2	1.5	1.7	0.5	0.89	0.10	0.20	28.73	0.28	0.43	45.30
SI	0.6	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.2	0.0	0.0	0.0	0.06	0.02	0.05	0.03	25.23	0.15	27.36
SK	0.7	0.1	0.1	0.8	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.2	0.0	0.1	0.1	0.1	0.1	0.48	0.03	0.14	0.08	0.29	17.80	22.70
Total	95.5	400.0	15.3	75.7	267.2	102.0	23.1	80.5	32.7	147.3	273.5	37.4	44.3	78.2	130.1	26.8	21.7	422.4	56.72	48.83	20.48	42.53	53.92	40.80	2537.25

Note: Values below 50,000 Euros are shown as 0.0. but are considered in the total.

Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

Table 6. Spillover matrix: contribution of each country to each other's market potential (as a percentage)

	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK
AT	66.18	0.13	2.20	4.96	0.56	0.41	1.20	0.32	0.72	0.27	0.11	0.93	6.35	0.26	0.80	1.27	1.28	0.12	1.31	0.33	2.04	0.69	9.23	7.33
BE	0.67	80.47	1.09	0.90	1.20	0.77	1.59	0.49	0.95	1.63	0.88	0.62	0.83	1.23	0.36	1.68	1.70	3.56	0.83	0.47	0.94	0.97	0.92	1.00
BG	0.05	0.00	40.52	0.05	0.01	0.02	0.07	0.03	0.04	0.01	0.00	0.39	0.16	0.01	0.03	0.07	0.07	0.00	0.05	0.03	1.15	0.04	0.10	0.13
CZ	2.04	0.07	0.98	53.85	0.36	0.33	0.91	0.13	0.53	0.12	0.06	0.36	1.59	0.15	0.16	1.02	0.98	0.07	2.05	0.14	0.95	0.52	1.14	4.49
DE	13.75	5.66	10.29	21.19	88.93	12.19	14.96	2.83	8.69	5.97	2.16	4.85	9.67	4.36	2.98	16.52	16.03	5.87	15.66	2.88	9.14	9.18	10.40	12.53
DK	0.35	0.13	0.72	0.70	0.43	74.37	3.53	0.15	1.79	0.17	0.12	0.28	0.58	0.27	0.13	4.56	3.65	0.16	1.30	0.17	0.66	2.80	0.44	0.82
EE	0.02	0.00	0.04	0.03	0.01	0.05	32.14	0.01	0.45	0.01	0.00	0.02	0.03	0.01	0.01	0.31	1.32	0.00	0.07	0.01	0.04	0.26	0.02	0.04
ES	0.96	0.28	4.08	0.91	0.34	0.52	1.59	80.27	1.03	2.14	0.32	2.80	1.60	0.81	1.50	1.53	1.70	0.23	0.86	9.81	2.65	0.92	2.05	1.56
FI	0.16	0.04	0.46	0.28	0.08	0.45	7.40	0.08	62.98	0.07	0.04	0.17	0.32	0.12	0.06	2.05	4.02	0.04	0.58	0.09	0.42	3.14	0.22	0.44
FR	2.80	3.25	6.83	3.12	2.52	2.00	5.23	7.49	3.26	81.31	1.89	4.46	3.79	3.75	4.23	5.24	5.59	1.50	2.76	4.03	4.95	3.09	4.62	4.16
GB	1.83	2.88	4.00	2.54	1.50	2.36	5.66	1.82	3.47	3.10	91.50	2.21	2.64	21.28	1.11	5.79	6.05	2.86	2.74	1.93	3.35	3.38	2.66	3.20
GR	0.25	0.03	5.13	0.24	0.05	0.09	0.33	0.26	0.21	0.12	0.04	70.04	0.67	0.10	0.35	0.33	0.36	0.03	0.24	0.26	1.31	0.18	0.61	0.55
HU	0.97	0.02	1.17	0.59	0.06	0.10	0.37	0.08	0.23	0.06	0.02	0.38	56.39	0.06	0.12	0.42	0.41	0.02	0.46	0.09	2.16	0.20	1.70	4.25
IE	0.12	0.11	0.30	0.16	0.08	0.14	0.38	0.12	0.24	0.16	0.56	0.16	0.18	63.48	0.07	0.38	0.41	0.10	0.18	0.14	0.25	0.23	0.18	0.22
IT	5.75	0.50	10.73	2.86	0.88	1.11	3.42	3.66	2.16	2.95	0.47	9.27	5.76	1.20	86.73	3.39	3.65	0.41	2.34	3.03	6.97	1.97	14.60	5.14
LT	0.04	0.01	0.10	0.07	0.02	0.15	0.68	0.02	0.28	0.01	0.01	0.04	0.08	0.02	0.01	36.24	2.31	0.01	0.32	0.02	0.09	0.29	0.05	0.12
LV	0.02	0.01	0.06	0.04	0.01	0.07	1.55	0.01	0.29	0.01	0.01	0.02	0.04	0.01	0.01	1.23	34.50	0.01	0.09	0.01	0.05	0.20	0.03	0.06
NL	1.05	6.10	1.75	1.55	2.13	1.61	3.02	0.69	1.78	1.29	1.50	0.91	1.35	2.05	0.50	3.27	3.23	84.67	1.54	0.69	1.52	1.86	1.43	1.70
PL	0.96	0.12	1.87	3.67	0.47	1.12	3.70	0.22	1.99	0.20	0.12	0.65	2.23	0.30	0.24	8.03	4.10	0.13	63.73	0.25	1.92	2.01	1.19	6.37
PT	0.10	0.03	0.45	0.10	0.03	0.06	0.19	0.97	0.13	0.11	0.03	0.28	0.17	0.09	0.12	0.18	0.20	0.02	0.10	75.20	0.30	0.11	0.20	0.17
RO	0.19	0.02	5.26	0.22	0.04	0.07	0.29	0.08	0.18	0.05	0.02	0.45	1.33	0.05	0.09	0.31	0.32	0.02	0.25	0.10	57.23	0.16	0.35	0.66
SE	0.39	0.11	1.04	0.73	0.22	1.87	11.33	0.18	8.35	0.17	0.11	0.38	0.76	0.29	0.16	5.66	7.64	0.12	1.57	0.21	0.96	67.56	0.53	1.07
SI	0.63	0.01	0.33	0.19	0.03	0.04	0.11	0.05	0.07	0.03	0.01	0.15	0.76	0.03	0.14	0.12	0.12	0.01	0.11	0.05	0.25	0.06	46.79	0.37
SK	0.72	0.02	0.61	1.07	0.05	0.09	0.34	0.05	0.20	0.04	0.02	0.20	2.73	0.05	0.07	0.39	0.37	0.02	0.85	0.06	0.69	0.18	0.54	43.64
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

In Table 5 it is evident that, excluding the main diagonal values, the row sum is equal to the market potential provided by each country to the rest of the countries, and the column sum is equal to the market potential received by each country from the rest of the countries. Table 8 compares both sums for each country. It can be seen, for example, that Germany and other big markets, such as France, the UK or Italy, provide more potential to other countries than they receive from them. For other countries the picture is just the opposite (more potential received than provided). This is particularly the case of small countries, such as the Baltic countries, Bulgaria and Slovenia, whose market potential composition depends largely on the contribution of other countries.

The spillover matrix of the market potential in relative terms (Table 6) was checked against the matrix of real proportional trade flows between countries in the EU (Table 10). The same operation was repeated for different market potential specifications. Table 11 evidences that, as expected, controlling for distance decay, border effect and non-adjacency increases the correlation coefficient between market potential and trade, leading to more realistic market potential estimations than assuming a distance decay value of 1 or calibrating distance decay without considering trade barriers.

Table 7. Coefficient of variation of the market potential received by each country

Country	Coefficient of variation
Austria	90.8
Belgium	208.3
Bulgaria	119.0
Czech R	214.4
Germany	144.0
Denmark	221.0
Estonia	127.2
Spain	197.3
Finland	145.7
France	177.6
Great Britain	167.3
Greece	165.2
Hungary	125.2
Ireland	274.2
Italy	176.9
Lithuania	132.7
Latvia	123.1
Netherlands	216.1
Poland	198.0
Portugal	201.0
Romania	121.3
Sweden	141.4
Slovenia	162.7
Slovakia	124.7

Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

Table 8. Market potential provided to/received from other European countries (in millions of market potential units)

Country	Provided to other countries	Received from other countries	Difference received - provided	Ratio received / provided
Austria	23	32	9	1.4
Belgium	31	78	47	2.5
Bulgaria	1	9	8	9.6
Czech R	11	35	24	3.3
Germany	162	30	-132	0.2
Denmark	11	26	15	2.4
Estonia	1	16	15	16.9
Spain	24	16	-8	0.7
Finland	7	12	5	1.7
France	72	28	-45	0.4
Great Britain	73	23	-50	0.3
Greece	4	11	7	2.5
Hungary	6	19	13	3.0
Ireland	4	29	24	6.4
Italy	50	17	-33	0.3
Lithuania	2	17	15	10.1
Latvia	1	14	13	11.5
Netherlands	51	65	14	1.3
Poland	19	21	1	1.1
Portugal	3	12	10	4.7
Romania	4	9	5	2.5
Sweden	17	14	-3	0.8
Slovenia	2	29	27	13.5
Slovakia	5	23	18	4.7

Source: authors' calculations from WIOD, EUROSTAT, Database of European roads 1957-2012 and GISCO.

Table 9. Real trade flow matrix (in millions of Euros)

	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK	Total
AT	74537	1207	644	3563	35065	493	51	2023	472	4514	3267	486	4100	179	7978	90	73	1167	2560	259	1696	1192	1226	931	147773
BE	1692	47608	320	1635	37010	1868	92	5790	1471	29533	17886	1591	1180	957	11586	238	135	22595	2889	1054	815	3942	220	339	192447
BG	212	475	20941	127	1323	51	2	316	21	521	184	761	102	7	1258	13	12	80	233	47	957	38	70	33	27783
CZ	5770	1719	356	69559	32820	622	63	2297	545	5780	4898	289	2186	220	4165	161	81	1948	5047	291	990	1308	383	4652	146149
DE	48995	29898	2477	26796	831117	13147	615	31823	8176	93549	59817	6154	16551	3826	61920	1342	820	39639	34008	6342	7484	21443	2796	7233	1355967
DK	465	699	86	664	10795	34368	87	1756	1662	2783	7725	485	281	475	1993	256	170	1609	1985	247	334	9224	50	184	78382
EE	23	65	4	39	383	140	3148	27	1134	130	112	4	11	5	121	297	391	89	120	3	8	843	4	12	7112
ES	1981	6059	427	1855	25117	964	59	367965	816	35879	13066	1959	791	724	19537	180	90	5128	3051	16464	1103	1802	470	479	505968
FI	457	1191	50	327	7026	1452	631	1205	73240	2004	2760	191	251	121	1309	343	342	2051	1383	97	119	5839	65	94	102549
FR	3502	23679	821	3506	66743	2187	121	29208	1734	598894	27541	2712	2561	1989	33018	263	182	11287	6551	3533	2565	5934	749	1502	830785
GB	1827	11180	300	1877	39662	5756	230	12220	1803	25080	306142	1553	1301	14038	11417	192	112	20353	3879	1437	1133	7122	241	523	469378
GR	64	110	506	60	937	60	2	319	89	354	320	59391	37	17	887	5	2	123	235	40	229	59	43	29	63920
HU	2976	670	610	2103	17590	404	52	1998	164	3451	3710	266	42318	111	3233	68	87	854	2488	226	3438	847	409	1573	89648
IE	376	3993	45	601	10205	663	34	2422	236	5013	11591	201	239	46458	2123	26	13	1660	584	348	176	1392	45	164	88606
IT	8357	5969	1297	3993	49783	2034	178	21042	1419	37461	16315	5121	3041	721	615158	440	216	4629	7980	2674	5057	3253	2782	1446	800366
LT	50	124	21	75	1081	244	245	129	182	725	381	14	36	32	218	8724	899	432	650	25	29	389	5	18	14728
LV	16	30	7	26	381	122	217	41	169	71	143	5	11	83	53	507	4638	51	101	1	14	239	2	8	6934
NL	2953	39939	463	2424	69216	4772	153	9656	3109	21626	29536	2237	2225	2404	19904	532	243	84418	4800	2056	1186	5648	306	502	310307
PL	2297	2171	456	7143	35775	2092	369	3678	995	8346	9140	434	3335	544	7969	1847	631	3263	159638	363	1906	3549	388	1763	258093
PT	322	762	24	241	3783	130	8	7210	155	3761	1624	107	95	86	1197	11	7	759	306	56979	125	310	27	62	78089
RO	643	272	925	419	4827	79	8	657	43	1772	816	298	1232	31	3099	11	9	433	659	62	74516	154	100	224	91289
SE	1259	3951	143	903	14488	9006	424	2635	7753	6309	8220	413	791	418	3594	498	235	4176	2886	494	224	109266	108	232	178427
SI	834	93	133	357	3698	143	14	197	47	1150	314	94	548	10	1632	20	19	133	410	26	263	126	7806	156	18223
SK	2317	338	209	4342	8339	203	12	1380	100	2366	1364	134	2435	36	2189	66	49	408	2327	80	572	870	180	19747	50063
Total	161928	182201	31266	132632	1307166	80999	6816	505994	105534	891074	526872	84900	85654	73491	815559	16129	9455	207286	244770	93146	104937	184790	18476	41908	5912984

Source: WIOD.

Table 10. Real trade flow matrix (as a percentage)

	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LV	NL	PL	PT	RO	SE	SI	SK
AT	50.44	0.88	0.76	3.95	3.61	0.59	0.32	0.39	0.45	0.42	0.39	0.10	3.32	0.42	1.04	0.34	0.23	0.95	0.89	0.41	0.70	0.71	4.58	4.63
BE	0.82	24.74	1.71	1.18	2.20	0.89	0.91	1.20	1.16	2.85	2.38	0.17	0.75	4.51	0.75	0.84	0.43	12.87	0.84	0.98	0.30	2.21	0.51	0.68
BG	0.44	0.17	75.38	0.24	0.18	0.11	0.06	0.08	0.05	0.10	0.06	0.79	0.68	0.05	0.16	0.15	0.11	0.15	0.18	0.03	1.01	0.08	0.73	0.42
CZ	2.41	0.85	0.46	47.59	1.98	0.85	0.55	0.37	0.32	0.42	0.40	0.09	2.35	0.68	0.50	0.51	0.38	0.78	2.77	0.31	0.46	0.51	1.96	8.67
DE	23.73	19.23	4.76	22.46	61.29	13.77	5.39	4.96	6.85	8.03	8.45	1.47	19.62	11.52	6.22	7.34	5.49	22.31	13.86	4.84	5.29	8.12	20.29	16.66
DK	0.33	0.97	0.19	0.43	0.97	43.85	1.96	0.19	1.42	0.26	1.23	0.09	0.45	0.75	0.25	1.66	1.76	1.54	0.81	0.17	0.09	5.05	0.79	0.40
EE	0.03	0.05	0.01	0.04	0.05	0.11	44.27	0.01	0.62	0.01	0.05	0.00	0.06	0.04	0.02	1.66	3.13	0.05	0.14	0.01	0.01	0.24	0.08	0.02
ES	1.37	3.01	1.14	1.57	2.35	2.24	0.38	72.72	1.18	3.52	2.60	0.50	2.23	2.73	2.63	0.87	0.59	3.11	1.43	9.23	0.72	1.48	1.08	2.76
FI	0.32	0.76	0.07	0.37	0.60	2.12	15.95	0.16	71.42	0.21	0.38	0.14	0.18	0.27	0.18	1.23	2.43	1.00	0.39	0.20	0.05	4.35	0.26	0.20
FR	3.05	15.35	1.88	3.95	6.90	3.55	1.83	7.09	1.95	72.09	5.34	0.55	3.85	5.66	4.68	4.92	1.02	6.97	3.23	4.82	1.94	3.54	6.31	4.73
GB	2.21	9.29	0.66	3.35	4.41	9.86	1.57	2.58	2.69	3.32	65.22	0.50	4.14	13.08	2.04	2.59	2.06	9.52	3.54	2.08	0.89	4.61	1.72	2.72
GR	0.33	0.83	2.74	0.20	0.45	0.62	0.05	0.39	0.19	0.33	0.33	92.91	0.30	0.23	0.64	0.10	0.07	0.72	0.17	0.14	0.33	0.23	0.52	0.27
HU	2.77	0.61	0.37	1.50	1.22	0.36	0.15	0.16	0.25	0.31	0.28	0.06	47.20	0.27	0.38	0.24	0.15	0.72	1.29	0.12	1.35	0.44	3.01	4.86
IE	0.12	0.50	0.02	0.15	0.28	0.61	0.06	0.14	0.12	0.24	2.99	0.03	0.12	52.43	0.09	0.22	1.20	0.77	0.21	0.11	0.03	0.23	0.05	0.07
IT	5.40	6.02	4.53	2.85	4.57	2.54	1.71	3.86	1.28	3.97	2.43	1.39	3.61	2.40	76.86	1.48	0.77	6.41	3.09	1.53	3.39	2.01	8.96	4.37
LT	0.06	0.12	0.05	0.11	0.10	0.33	4.18	0.04	0.33	0.03	0.04	0.01	0.08	0.03	0.05	59.24	7.31	0.17	0.72	0.01	0.01	0.28	0.11	0.13
LV	0.05	0.07	0.04	0.06	0.06	0.22	5.50	0.02	0.33	0.02	0.02	0.00	0.10	0.01	0.03	6.10	66.88	0.08	0.24	0.01	0.01	0.13	0.11	0.10
NL	0.79	11.74	0.29	1.33	2.92	2.05	1.25	1.01	2.00	1.36	4.34	0.19	0.95	1.87	0.58	2.94	0.73	27.20	1.26	0.97	0.47	2.34	0.73	0.82
PL	1.73	1.50	0.84	3.45	2.51	2.53	1.69	0.60	1.35	0.79	0.83	0.37	2.77	0.66	1.00	4.41	1.46	1.55	61.85	0.39	0.72	1.62	2.25	4.65
PT	0.18	0.55	0.17	0.20	0.47	0.31	0.04	3.25	0.09	0.43	0.31	0.06	0.25	0.39	0.33	0.17	0.02	0.66	0.14	72.97	0.07	0.28	0.14	0.16
RO	1.15	0.42	3.44	0.68	0.55	0.43	0.11	0.22	0.12	0.31	0.24	0.36	3.84	0.20	0.63	0.20	0.20	0.38	0.74	0.16	81.63	0.13	1.44	1.14
SE	0.81	2.05	0.14	0.89	1.58	11.77	11.85	0.36	5.69	0.71	1.52	0.09	0.95	1.57	0.41	2.64	3.45	1.82	1.38	0.40	0.17	61.24	0.69	1.74
SI	0.83	0.11	0.25	0.26	0.21	0.06	0.05	0.09	0.06	0.09	0.05	0.07	0.46	0.05	0.35	0.03	0.02	0.10	0.15	0.03	0.11	0.06	42.84	0.36
SK	0.63	0.18	0.12	3.18	0.53	0.23	0.17	0.09	0.09	0.18	0.11	0.05	1.75	0.18	0.18	0.12	0.12	0.16	0.68	0.08	0.25	0.13	0.86	39.45
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: WIOD.

Table 11. Correlation coefficients between the actual international trade matrix and market potential matrices

Market potential specification	Pearson's correlation coefficient	Sig.
Non-calibrated market potential: Distance decay = 1	0.416	0.042
Model 0: Calibrating distance decay without trade barriers = 2.127	0.741	0.000
Model II: Calibrating distance decay and trade barriers: Introducing calibrated distance decay = 1.676	0.620	0.001
Introducing calibrated border effect = 6.931	0.892	0.000
Introducing calibrated non-adjacency = 1.575	0.915	0.000

5. Final remarks

This research attempts to integrate two scientific traditions that have evolved separately: market potential and border effect. Market potential studies assume that trade decreases progressively with distance (the distance decay parameter). However research on the border effect shows that borders cause trade to fall abruptly, particularly between non-adjacent countries. This means that only calibrating the distance decay parameter without considering trade barriers leads to a misspecification of the potential market model due to an overestimation of the distance decay, and thus ignoring the actual behaviour of goods at borders. In this paper different impedance parameters (distance decay and trade barriers) were calibrated using a gravity equation and were then introduced into the market potential model, leading to a discontinuous function instead to a continuous one.

It has been shown that the assumption of the value 1 for the distance decay parameter (common in market potential studies in the European Union using a negative potential function) distorts accessibility values, thereby overestimating relationships over long distances. Instead, introducing the calibrated impedance parameters (distance decay and trade barriers) in the market potential model leads to more realistic results, dramatically increasing self-potential values and spatial disparities in market potential distribution. The effect of the calibrated distance decay parameter is more intense in peripheral regions, while the densest ones (main urban regions) tend to experience lower losses. Border and non-adjacency effects especially affect sparsely populated border regions, which are highly dependent on the market potential received from other countries.

The market potential decomposed matrix (equivalent to a spillover matrix) allows the market potential that a country receives from others to be identified. This value depends on a set of factors, such as GDP and geographical location. Logically, a small country located near a big market tends to receive a high potential value from this big market. Results show that countries with higher GDP values exhibit higher self-potential values and are less dependent on the market potential that they receive from others. Meanwhile, the matrix shows the degree of concentration of the potential that a country receives from other countries, thus evidencing the degree of dependency from the largest contributors. This is significant from the point of view of the vulnerability of a country's exports. Finally, the high correlation coefficient between the actual exports matrix and the market potential composition evidences the realism of the market potential specification proposed and the spillovers matrix presented.

It has been demonstrated that potential market studies in an international framework should take into account not only the distance deterrence, but also the effect of trade barriers. Introducing calibrated distance decay and trade barriers in the market potential model leads to a better modelling of economic flows. The consideration of these impedance parameters enables longitudinal studies to be produced in order to evaluate not only the impact of transport policies (e.g. the extension of trans-European networks) but also to assess the effect of the progressively diminishing role of borders on market potential. This is a subject for further research.

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References

Anderson, J.E. and van Wincoop, E. (2001). *Gravity with Gravitas: A Solution to the Border Puzzle*. National Bureau of Economic Research, Inc.

Bivand, R. (1998). *A Review of Spatial Statistical Techniques for Location Studies*. Norwegian School of Economics and Business Administration, Bergen.

Bruinsma, F. and Rietveld, P. (1998). The accessibility of European cities: theoretical framework and comparison of approaches. *Environment and Planning A*, 30 (3), 499-521.

Chen, N. (2004). Intra-national versus international trade in the European Union: why do national borders matter? *Journal of International Economics,* 63 (1), 93-118.

Clark, W.A. and Hosking, P.L. (1986). *Statistical Methods for Geographers*. Wiley, New York.

Clark, C., Wilson, F. and Bradley, J. (1969). Industrial location and economic potential in Western Europe. *Regional Studies*, 3 (2), 197-212.

Clark, T.E. and van Wincoop, E. (2001). Borders and business cycles. *Journal of International Economics*, 55 (1), 59-85.

Condeço-Melhorado, A., Gutiérrez Puebla, J. and García Palomares, J. (2013). Influence of distance decay on the measurement of spillover effects of transport infrastructure: A sensitivity analysis. *GeoFocus (Artículos),* 13 (1), 22-47.

Condeço-Melhorado, A., Tillema, T., de Jong, T. and Koopal, R. (2014). Distributive effects of new highway infrastructure in the Netherlands: the role of network effects and spatial spillovers. *Journal of Transport Geography*, 34, 96-105.

ESPON. (2005). *ESPON Project 2.1.1. Territorial Impact of EU Transport and TEN Policies. Final Report*. European Spatial Planning Observation Network.

ESPON. (2006). *ESPON 3.4.3. The Modifiable Areas Unit Problem. Final Report*. European Spatial Planning Observation Network.

ESPON. (2007). *Update of Selected Potential Accessibility Indicators. Final report. February 2007*. Spiekermann and Wegener Urban and Regional Research (SandW) RRG Spatial Planning and Geoinformation.

ESPON. (2009). *Territorial Dynamics in Europe: Trends in Accessibility*. Available at: http://www.espon.eu/export/sites/default/Documents/Publications/TerritorialObservations/TrendsInAccessibility/to-no2.pdf.

ESPON. (2011). *TRACC Transport Accessibility at Regional/Local Scale and Patterns in Europe. Applied Research 2013/1/10. Interim Report. Version 21/02/2011.* European Spatial Planning Observation Network.

European Commission. (2006). *Statistics on the trading of goods – User guide*. Office for Official Publications of the European Communities, Luxembourg.

European Commission. (1999). *European Spatial Development Perspective. Towards Balanced and Sustainable Development of the Territory of the European Union.* Office for Official Publications of the European Communities, Luxembourg.

Forslund, U. M., and Johansson, B. (1995). Assessing road investments: accessibility changes, cost benefit and production effects. *Annals of Regional Science,* 29, 155-174.

Foster-McGregor, N., Stehrer, R., and Timmer, M. (2013). International fragmentation of production, trade and growth: Impacts and prospects for EU member states. *Research Report 387.*The Vienna Institute for International Economic Studies (WIIW).

Fotheringham, A.S. and O'Kelly, M.E. (1989). *Spatial Interaction Models: Formulations and Applications.* Kluwer Academic Publishers, Dordrecht.

Geertman, S.C.M. and Ritsema, V.E. (1995). GIS and models of accessibility potential: an application in planning. *International Journal of Geographical Information Systems*, 9 (1), 67-80.

Geurs, K.T. and van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, 12 (2), 127-140.

Gil-Pareja, S., Llorca-Vivero, R., Martínez-Serrano, J.A. and Oliver-Alonso, J. (2005). The Border Effect in Spain. *World Economy*, 28 (11), 1617-1631.

Griffith, D. A., (1992). What is spatial autocorrelation? Reflections on the past 25 years of spatial statistics. *Espace Géographique,* 21(3), 265-280.

Gutiérrez, J. (2001). Location, economic potential and daily accessibility: an analysis of the accessibility impact of the high-speed line Madrid–Barcelona–French border. *Journal of Transport Geography*, 9 (4), 229-242.

Gutiérrez, J., Condeço-Melhorado, A. and Martín, J.C. (2010). Using accessibility indicators and GIS to assess spatial spillovers of transport infrastructure investment, *Journal of Transport Geography*, 18 (1), 141-152.

Gutiérrez, J., Condeço-Melhorado, A., López, E. and Monzón, A. (2011). Evaluating the European added value of TEN-T projects: a methodological proposal based on spatial spillovers, accessibility and GIS. *Journal of Transport Geography*, 19 (4), 840-850.Gutiérrez, J. and Urbano, P. (1996). Accessibility in the European Union: the impact of the trans-European road network. *Journal of Transport Geography*, 4 (1), 15-25.

Hansen, W.G. (1959). How Accessibility Shapes Land Use. *Journal of the American Institute of Planners*, 25 (2), 73-76.

Harris, C.D. (1954). The Market as a Factor in the Localization of Industry in the United States. *Annals of the Association of American Geographers*, 44 (4), 315-348.

Haynes, K.E. and Fotheringham, A.S. (1984). *Gravity and Spatial Interaction Models.* Sage publications, Beverly Hills.

Head, K. and Mayer, T. (2004). Market potential and the location of Japanese investment in the European Union. *Review of Economics and Statistics*, 86 (4), 959-972.

Head, K. and Mayer, T. (2002). *Illusory Border Effects, Distance Mismeasurement Inflates Estimates of Home Bias in Trade.* Centre d'études prospectives et d'informations internationales, Paris.

Head, K. and Mayer, T. (2000). Non-Europe: The magnitude and causes of market fragmentation in the EU. *Review of World Economics (Weltwirtschaftliches Archiv),* 136, (2), 284-314.

Hillberry, R. and Hummels, D. (2003). Intranational Home Bias: Some Explanations. *The Review of Economics and Statistics*, 85, (4), 1089-1092.

Holl, A.(2011).Mejoras de accesibilidad viaria: un estudio retrospectivo para la España peninsular. *Papeles de Geografía*, 53-54, 171-183.

Holl, A. (2007). Transport network development and the location of economic activity. In Coto-Millán, P. and Inglada, V.P. (eds) *Essays on Transport Economics,* Physica-Verlag HD, 341-361.

Keeble, D., Offord, J. and Walker, S. (1988). *Peripheral Regions in a Community of Twelve Member States.* Office for Official Publications of the European Communities.

Kendall, M. G., (1939). The geographical distribution of crop productivity in England. *Journal of the Royal Statistical Society,* 102 (1), 21-62.

Linneker, B. (1997). *Transport Infrastructure and Regional Economic Development in Europe: A Review of Theoretical and Methodological Approaches.* University of Sheffield, Department of Town and Regional Planning.

López, E., J. Gutiérrez, and G. Gómez (2008). Measuring regional cohesion effects of large-scale transport infrastructure investments: an accessibility approach. *European Planning Studies,* 16, 277-301.

López, E., Monzón, A., Ortega, E. and Mancebo Quintana, S. (2009). Assessment of Cross-Border Spillover Effects of National Transport Infrastructure Plans: An Accessibility Approach. *Transport Reviews*, 29 (4), 515-536.

Lutter, H., Pütz, T. and Spangenberg, M. (1992). *Accessibility and Peripherality of Community Regions: The Role of Road, Long-Distance Railways and Airport Networks, Report to the European Commission.* DG XVI, Bonn, Bundesforschungsanstalt für Landeskunde und Raumordnung.

McCallum, J. (1995). National Borders Matter: Canada-U.S. Regional Trade Patterns. *American Economic Review*, *American Economic Association*,85 (3), 615-623.

Nitsch, V. (2000). National borders and international trade: Evidence from the European Union. *The Canadian Journal of Economics / Revue canadienne d'Economique*, 33 (4), 1091-1105.

O'Kelly, M.E. and Horner, M.W. (2003). Aggregate accessibility to population at the county level: U.S. 1940-2000. *Journal of Geographical Systems*, 5 (1), 5-23.

ONS (2009). *United Kingdom Balance of Payments. The Pink Book.* Office for National Statistics, Totton, Southampton, UK.

Östh, J., Andersson, E. and Malmberg, B. (2013). School choice and increasing performance difference: A counterfactual approach. *Urban Studies*, 50 (2), 407-425.

Reggiani, A. and Bucci, P. (2008). Accessibility and impedance forms: empirical applications to the German commuting network. Paper presented at the *NARSC Conference*, Nov. 2008.

Reggiani, A., Bucci, P. and Russo, G. (2011). Accessibility and Impedance Forms: Empirical Applications to the German Commuting Network. *International Regional Science Review*, 34 (2), 230-252.

Salas-Olmedo, M.H., Condeço-Melhorado, A. and Gutiérrez, J. (In Press). Border effect and market potential: the case of the European Union. In Condeço-Melhorado, A., Reggiani, A. and Gutiérrez, J. (eds) *Accessibility and spatial interaction*, Edward Elgar, NECTAR Series, Spain.

Spence, N. and Linneker, B. (1994). Evolution of the motorway network and changing levels of accessibility in Great Britain. *Journal of Transport Geography*, 2 (4), 247-264.

Spiekermann, K. and Neubauer, J. (2002). *European Accessibility and Peripherality: Concepts, Models and Indicators*. Nordregio, Stockholm.

Stelder, D. (2013). *Changes in Road Infrastructure and Accessibility in Europe since 1960. Final Report Revision and additions*. September, 2013, European Commission Directorate-General Regional Policy Policy development Economic and quantitative analysis.

Stepniak, M., and Rosik, P. (2013). Accessibility improvement, territorial cohesion and spillovers: a multidimensional evaluation of two motorway sections in Poland. *Journal of Transport Geography*, 31, 154-163.

Tagai, G., Pénzes, J. and Molnar, E. (2008). Methods of the analysis of integration effect on border areas - the case of Hungary. *Eurolimes*, 6, 150-159.

Timmer, MP. (ed) (2012). The World Input-Output Database (WIOD): Contents, Sources and Methods. *WIOD Working Paper Number 10*, downloadable at: http://www.wiod.org/publications/papers/wiod10.pdf

Wegener, M., Eskelinnen, H., Fürst, F., Schürmann, C. and Spiekermann, K. (2000). *Indicators of Geographical Position. Final Report of the Working Group "Geographical Position" of the Study Programme on European Spatial Planning*. IRPUD, Dortmund.

Wegener, M. and Bökemann, D. (1998). The SASI Model: Model Structure, *SASI Deliverable D*, 8.

Wegener, M. (2001). *Criteria for the Spatial Differentiation of the EU Territory: Geographical Position: Study Programme on European Spatial Planning*. Federal Office for Building and Planning.

Wei, S. (1996). *Intra-National versus International Trade: How Stubborn are Nations in Global Integration?* National Bureau of Economic Research, Inc.

Wolf, H.C. (2000). Intranational Home Bias in Trade. *The Review of Economics and Statistics*, 82 (4), 555-563.

Wolf, H.C. (1997). *Patterns of Intra- and Inter-State Trade.* National Bureau of Economic Research, Inc.

Yoshida, N. and Deichmann, U. (2009). Measurement of Accessibility and Its Applications. *Journal of Infrastructure Development*, 1(1), 1-16.