Is the European Border Puzzle Dead at Last? A Structural Gravity Approach using Regionalised EU27 Trade Data

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Abstract – Despite the methodological and theoretical advances made in structural gravity modelling, which largely 'resolved' the US-Canadian border puzzle, border effect estimates for the EU's internal borders have remained puzzlingly large. This paper investigates and demonstrates that the reason why these border effect estimates remain so large in comparison to the US-Canadian border effect estimates, is inherently related to the difference in the geographical level at which trade data has been measured and used by EU border effect studies. Using both regional-level trade flows derived from a unique set of regionalised IO tables for the EU27 at the NUTS2 level over the period 2000-2010, as well as self-constructed adjacency and distance matrices at this level of geographical aggregation, this study estimates a set of structural gravity models with importer-time, exporter-time and dyadic fixed effects by resorting to Poisson Pseudo Maximum Likelihood. I document that the border effects are considerably lower as opposed to studies that only use national-level trade flow data. Those studies frequently find border effect estimates around the 10 in magnitude, but regionalised trade data shrinks these estimates to only 2 for trade in goods. This implies that regions trade on average, across the EU, only 2 times more with a region within the same nation as opposed to a similar region, in size (total regional production value) and distance, across the national border. Trade in services is however subject to higher border frictions, albeit it markedly higher in the EU15 than in the EU12. I additionally also investigate the extent to which the Euro has been able to reduce these border effects, but this study finds no statistical evidence that the introduction of the Euro fostered closer economic integration in the short-run. I conclude with a note of caution against studies that endeavour to assess border effects using exclusively national-level data, as estimates are likely overstated in the presence of regional border effects that could arise from geospatial clustering of firms. Unfortunately, this critique does not only apply to EU border effect studies, but it additionally invalidates most non US-Canadian border effect studies as well (*id est* African and Asian border effect studies).

I. Introduction

One of the most puzzling findings in all of international economics has been the fact that national borders appear to have been highly inconducive to international trade, even in regions such as the EU and North America where most border impediments such as tariffs have been removed (Obstfeld & Rogoff, 2000). Whilst border frictions were expected, even in such integrated regions of the world, the estimates seemingly revealed that Canadian regions traded 22 (!) times more with each other as opposed with US states of similar size (in terms of the value of production) and at a similar distance (McCallum, 1995). In response, other studies by Nitsch (2003) and Head and Mayer (2000) extended the scope of the border effect literature to other regions such as the EU, finding border effects in excess of 10 in magnitude. Astonished by the existence of such prominent border effects, consecutive research proposed various methodological and theoretical improvements with respect to the measurement of these border effects, which led to smaller border effect estimates (around the 5 in magnitude) for the US-Canadian border and effectively resolved the "border puzzle" for North America (Anderson & Van Wincoop, 2003).

Despite these more recent methodological and theoretical advancements that proved essential in explaining the border puzzle for North America, it seemingly did little to resolve the border puzzle that arose in the EU as contemporary studies by Cheptea (2013) and Mika (2017) still document border effects that are quantitively similar to those obtained by for instance Head and Mayer (2000) and Nitsch (2003)[1]. As such, research into EU border effects has more frequently been directed at explaining these unexpectedly large border effect estimates. Unfortunately, intuitive national trade barrier based explanations such as different national currencies and other non-tariff barriers (NTB's) have found remarkably little empirical support in the case of the EU (Chen, 2004), and more recent alternatives, such as 'isolation legacy' effects as proposed by Head and Mayer (2013), rely on explanations that are centred on factors and variables that cannot be easily measured. With few evident avenues left for *empirical* studies and no consensus in sight, the "border puzzle" might thus have been resolved for the US-Canadian border as Anderson and Van Wincoop (2003) proclaimed, but it remains very much a puzzle for the case of the EU.

[1] Note however, that some articles (Chen, 2004; Minondo, 2007; Manchin & Pinna, 2009) that immediately followed the methodology proposed by US-Canadian border studies, such as Anderson and van Wincoop (2003) and Feenstra (2003), did have success in reducing the border effect to around the 7. Nonetheless, more recent articles, using similar or improved methodologies, by Cafiso (2011), Cheptea (2013) and Mika (2017) estimate effects that are around (or in excess of) 10 in magnitude.

This study revisits this puzzle for the EU by reflecting on the primary difference between North-American and EU study designs: the level of geographical aggregation of trade data used when studying border effects. Helble (2007) notes on that account that all studies pertaining to the US-Canadian border have drawn from trade data at the regional level (*id est* province and state level), whilst EU studies have generally had to content themselves with trade data on the national level as regional (sub-national) trade data for the EU has been extremely scarce. The main problem that arises from this lack of data is the absence of intranational trade flows which are by definition necessary to compute border effects as they have been expressed as the relative size of *intranational* to international trade flows. Using a unique and newly constructed regional trade dataset[2] for the EU, this study re-estimates these national border effects over the period 2000-2010 and investigates whether aggregation could be the last 'piece' to the EU's border puzzle. In addition this paper also revisits one of the primary national trade barrier based explanations of different currencies, by revisiting to what degree the Euro has mitigated border effects and how the introduction thereof has thus fostered economic integration in the Euro area. This study thus effectively tries to answer the question:

"How have national border effects developed across the European Single Market for goods and services over the period 2000-2010 and how has the Euro affected the European Union's economic integration?"

Using such regionalised data as opposed to national-level data, I find that border effects are considerably as opposed to studies that only use national-level trade flow data. Those studies frequently find border effect estimates around the 10 in magnitude, but regionalised trade data shrinks these estimates to only 2 for trade in goods across the EU27. This implies that regions trade on average, across the EU, only 2 times more with a region within the same nation as opposed to a similar region, in size (total regional production value) and distance, across the national border. Trade in services is however subject to higher border frictions, albeit it markedly higher in the EU15 than in the EU12. This study finds however no statistical evidence that the introduction of the Euro fostered closer economic integration in the short-run across Eurozone members and thus the EU in general. In light of these findings, it can be concluded that regionalised trade flow data might indeed have been the last piece to

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[2] Which uses the recent and unique set of regionalised IO tables provided by Thissen, Lankhuizen, Oort, Los, and Diodato (2018) for the EU27 over 2000-2010 to determine regional trade flows between 252 region within the EU and contains self-constructed distances between these regions as well as the other variables necessary for the estimation of a structural gravity model. See section III for a more thorough discussion of the construction of this dataset and appendix A for the corresponding data sources.

the EU's border effect puzzle. On the other hand, it ushers a warning to any studies undertaken to assess the border effect level using exclusively national-level trade data, as border effect estimates in such cases will most likely be severely overstated.

The proceeding literature review will present an account of the empirical findings on both EU border effects for the period 2000-2010 and the extent to which the introduction of the Euro has affected economic integration in the EU. Before presenting these findings though, I will first elaborate further on how the absence of regionalised trade data has affected empirical border effect research in the EU, how this data impediment has been dealt with and which caveats this method presents to the 'proper' estimation of border effects[3]. After both the discussion of the border's and that the Euro's effect on trade, this paper will construct some hypotheses that will be used to facilitate answering the main question as well as serve to juxtapose the findings of the national-level based border effect literature to those obtained by regional trade flow data. The subsequent section of this paper will elaborate on the methodology used to study these border and Euro effects on trade (structural gravity modelling) as well as how the dataset has been constructed. Section IV will present the results obtained from applying the gravity model to the data and section V will provide a conclusion and a consecutive discussion of the implications of this study as well as potentially fruitful avenues for future research.

II. Literature Review[4]

Part I: The Case for Regional Trade Data

As the *border effect* has commonly been expressed as the relative amount of intranational to international trade after correcting for distance between and the size of (in terms of production volume) both trading partners, it is evidently vital for border effect studies to possess data on both international as well as intranational trade. Trade data at a sub-national level (also referred to as the regional level in this study) for the EU has however been extremely rare and as such intranational trade flows have been unavailable for border effect research in the EU (Head & Mayer, 2002), except for a couple of specific countries such as France, Germany and Spain

[3] This discussion will primarily use earlier papers in the EU border effect literature. This has been done to also provide the readership with early estimates and thus with a perspective on the EU's border effect puzzle. Note, that as contemporary papers also rely on the same method to overcome this data impediment, this critique is not only valid for earlier work but also for more recent studies.

[4] Please note that most of the more technical discussions regarding the methodological concerns that stem from either (internal) distance measurement, multilateral resistance terms, zeros in trade or heteroskedasticity will be deferred until the methodology section.

(see for instance Helble (2007) for France-Germany and Gil-Pareja et al. (2005) for Spain-OECD). In order to overcome this difficulty, Wei (1996) proposed a novel and inventive way to circumvent the need for intranational trade flows by approximating it through subtracting a nation's exports from its domestic production, an approach that would be followed by nearly all studies into EU border effects thereafter.

However, Wei (1996), Head and Mayer (2000) and Nitsch (2003) noted that another data concern arose when resorting to his approximation to intranational trade flows: the measurement of internal distances. Whilst Wei's approach yielded intranational trade data, the estimation of border effects additionally requires the average distance travelled by every trade flow in order to (appropriately) account for transportation costs. Subsequent research by Head and Mayer (2000; 2002) and Nitsch (2003) provided alternative internal distance measures to the *ad hoc* solution proposed by Wei (1996), and were amongst the first to document the large sensitivity of national-level based studies to the measurement of internal distances[5]. As an example, Wei (1996) obtained estimates that implied that the EC had been highly integrated over the period 1982-1994, finding that intranational EC member trade was on average only 1.7 times between EC member trade. Head and Mayer (2000) and Nitsch (2003) document in contrast, using more reliable internal distance estimates, that the average border effect estimate amongst EC members was puzzlingly large, being on average around 11 in magnitude. On the other hand, regional-level studies into border effects mitigate this problem as the regions provide enough variation in trade to estimate the average national border effect, whilst requiring only *observed* inter-regional distances (using for instance distance from regional capital to regional capital).

Whilst the regional-level might only offer a slight advantage as internal distance measures by Head and Mayer (2000) probably reflect the true internal distance travelled by intranational trade flows to a relatively accurate degree, it might offer a larger advantage in the presence of inter-regional borders. Both Wolf (2000) and Novy and Coughlin (2012) have documented the existence of inter-regional border effects for the US due to the geographical clustering of firms and their suppliers. The problem that arises when regional borders exist, especially if firms cluster geographically, is the fact that if one abstracts from the regional-level trade flows towards the national-level trade flows, the gravity model, and thus the border effect estimate, can no longer incorporate the fact the some border effects might be inherent to regional borders, which would consecutively end up in the national border

[5] Note that this has also been confirmed by other more recent studies such as Chen (2004) and Havranek and Irsova (2017).

effect estimate and thus inflate it artificially. This would imply that as one increases the level of geographical detail to the regional-level, one could properly estimate what is truly due to national borders and what is due to regional borders (*id est* clustering). Whilst Chen (2004) does not emphasise this inherent threat to border effect estimation using national-level trade flows, she does provide evidence that clustering of firms might in fact explain a part of the border effects in the EU, which would imply border effect estimates might be overestimated as the observed clustering is in the most likely instance not only national, but regional as well.

From the preceding line of reasoning, I belief it is apparent why one needs to resort to regional-level data to truly assess national border effects instead of relying on national-level based proxies to intranational trade data as has been the standard for EU wide border effect studies. Regional-level trade data offers, in addition to capturing the actual degree of economic integration between EU members instead of a mixture of regional and national border effects, the fact that *national* border effect estimation does not rely on internal distance measurement. Whilst I have argued this using studies that cover the period before the 2000s, this critique extends to *all* studies discussed in this paper except for US studies such as Wolf (2000) and Novy and Coughlin (2012) and the studies by Helble (2007) and Gil-Pareja et al. (2005).

Part II: Border effect estimates for the EU over 2000-2010

Cafiso (2011) was one of the earliest studies into border effects in the EU since the 2000s. Using an OLS importer and exporter fixed effects model, as proposed by Feenstra (2003; 2016) that incorporates the advancement made in gravity modelling by Anderson and van Wincoop (2003)[6], he estimates that that border effects have declined from 9.6 in magnitude towards 9 over the period 2000-2003. It must however be noted that OLS estimation (with fixed effects as well) suffers from two potential sources of bias: heteroskedasticity in the errors and the censuring of zero trade flows as OLS requires taking the natural log of trade flows[7]. More recent estimations have instead resorted to Poisson Pseudo Maximum Likelihood (PPML)

[6] Anderson and van Wincoop (2003) derive the gravity model theoretically and show that one must account for multilateral resistance terms that reflect the importer's relative ease to import from the exporter compared to all other regions and exporter's relative ease of exporting to the importer compared to all other regions. Whilst Anderson and van Wincoop resort to custom programming to properly account for these terms, Feenstra (2003; 2016) shows that importer and exporter fixed effects estimators also provide consistent estimates. To see why and how exactly, I refer the readership to the Methodology and Data section where this has been illustrated for this paper's gravity model.

[7] For a more detailed elaboration on both issues, I refer the readership to the Methodology and Data section where both concerns have been addressed and incorporated in this paper's empirical model.

with importer and exporter fixed effects, as recommended by Silva and Tenreyro (2006) and Feenstra (2016), to overcome both difficulties and subsequently find somewhat higher border effect estimates. Martínez San Román et al. (2012) analyse for instance border effects across the EU over the period 1995-2006 by using PPML in conjunction with fixed effects. They find that border effects have increased by 22% up until 2000, yet regress by 35% across the subsequent period. In terms of absolute magnitude their border effects effectively range between the 11.3 and the 17.6.

In line therewith, Mika (2017) finds evidence in favour of considerable EU market fragmentation as well, documenting that border effects across the EU for goods are of a similar size to those obtained by Martínez San Román et al. (with a size of around 12.1 on average) and have continuously been decreasing over the period 2000-2014 with the notable exception of 2009, which coincides with the financial crisis (*id est* countries seemingly introverted during the crisis). However, Mika (2017) rejects the notion that trade in goods has become more integrated as the decline over time is not significant[8]. Cheptea (2013), using the a similar methodology as Martínez San Román et al. (2012) and Mika (2017), also investigates European economic integration by assessing EU border effects, and finds that these are in excess of 10 in magnitude over the period 1994-2007 as well. Jointly these studies suggest that, whilst based on national-level trade data for both international and intranational trade flows, the EU is considerably more fragmented than can easily be rationalised by border barriers, and as such are puzzlingly large for an area such as the EU that has implemented a comprehensive set of market integrating institutions.

Both Mika (2017) and Cheptea (2013) however add to this that there are some important additional factors to consider when estimating border effects for the EU. Whilst not unique to Mika's study, Mika (2017) as well as other authors such as Liu, Whalley and Xin (2010) warn for aggregating both service and goods trade data as border effects for trade in goods are by no means similar to border effects for trade in services. In fact, both Mika (2017) and Liu et al. (2010) report that the border effects in services are considerably larger. Cheptea (2013) on the other hand refers to another aggregation issue stemming from geographical heterogeneity. When allowing for added flexibility in the border effect estimation with respect to EU15 or EU12 membership[9], she documents that the markets of the EU15 and the EU12 have been subject to considerably heterogenous border effect levels. The border effect levels for

[8] Note however that Mika (2017) does not reject this notion of declining border effects for trade in services across the EU over the period 2000-2014.

[9] EU15 members are the 15 countries that were EU member states by 1995. The EU12 countries include by extension all recent entrants to the EU since 2004 with the exception of Croatia.

the EU15 and the EU12 were estimated by Cheptea (2013) to be around the 10 and 30 in magnitude, respectively. The growth rates over 2000 till 2007 implied however a moderate decrease in border effects for the EU15 at ~9% in total, compared to the staggering ~50% for the EU12 over that same period. In light of both concerns, when I estimate the average border effects for the EU, I will allow for a distinction in average border effects for both the EU12 and EU15 as well as whether the trade is in goods or in services to prevent obtaining some form of compounded border effect.

Based on the fact that most authors, which have documented the development of border effects in levels and changes (Cafiso, 2010; Martínez San Román et al. 2012; Cheptea, 2013; Mika, 2017), have reported that border effects have on average been either around 10 in magnitude or larger for goods trade across both the EU12 and EU15, I hypothesise that *the average national border effect for trade in goods has remained around 10 in magnitude by 2010*. As Mika (2017) and Liu, Whalley and Xin (2010) argue that service trade has had significantly larger border effects, I also hypothesise that *the average national border effect for trade in services has remained or exceeded the 10 in magnitude by 2010*. As this study also tries to describe how border effects have changed over time, I furthermore hypothesise that *national border effects for both trade in goods and services have significantly decreased over the period 2000-2010 for the EU12* based on Cheptea's (2013) evidence that EU12 border effects have been in sharp decline in conjunction with Mika's results that suggest that service trade has been characterized by decreasing border effects. On the other hand, I expect that the EU15 has not experienced a severe decline in border effects during 2000-2010 based on Cheptea (2013), and as such I hypothesise that *national border effects for trade in goods and services have not decreased significantly over the period 2000-2010 for the EU15*.

Part III: The EMU and its impact on EU Economic Integration

In addition to documenting border effects on trade, Cafiso (2011) also provides evidence on the effect of the Euro on trade as well. He finds that the Euro increases trade between European Monetary Union (EMU) members by on average 17.7% as compared to their pre-Euro trade volumes. These estimates are in line with a meta-study conducted by Rose (2017) for the purpose of analysing the EMU's effect across a multitude of studies, finding an *average* effect of around 20% increase in trade between European countries where the Euro is the official currency. Nonetheless, the meta-study by Rose (2017) was primarily aimed at offering an unifying explanation for the *wide* variation within the field of EMU effect estimation, as estimates vary between an 50% increase and a surprising -25% decrease in trade between EMU members. Some authors such as Baldwin (2006) have on that account asked "how big is the magic" (Baldwin, 2006, p. 36) when referring to the wide-spread estimated effect of currency unions on trade and economic integration. Havranek (2010) has in addition documented (using a funnel asymmetry test) that especially this branch of gravity modelling has severely been effected by publication bias, which would drive the average estimated effect of the Euro as obtained from a meta-analysis down to insignificantly different from zero.

In order to still draft a testable hypothesis despite the wide dispersion of these estimates, I concentrate on the type of models that have included dyadic effects to control for time-invariant endogeneity associated with Euro and EMU membership due to self-selection, and have adopted 'best practice estimation techniques' such as PPML and country specific fixed effects. Santos Silva and Tenreyro (2010) show that using these specifications yield marginally insignificant results that seem to have negative coefficients for EMU membership (if significant, this would imply that Euro membership would decrease trade between Eurozone members compared to if the region did not join the Euro). However, beyond the paper of Santos Silva and Tenreyro (2006), most other papers have not resorted to these practices. A paper by Figueiredo, Lima and Schaur (2016), which investigates the Euro's effect on trade using quantile regression analysis, reports however that there is no large heterogenous effect observable across trade flow sizes, providing little evidence for an heterogenous effects across the EU15 and the EU12. Remarkably, Figueiredo, Lima and Schaur (2016) also find negative estimates which are significant in some specifications that include only EEA countries (such as the sample used in this study), whilst the majority of estimates is insignificantly different from zero.

In answering the second part of the main question of "*how has the Euro affected the European Union's economic integration*?", I use the findings of Silva and Tenreyro (2010) as well as those of Figueiredo, Lima and Schaur (2016) to provide a testable hypothesis. Based on their results I deduce that *there is no significant total effect of the Euro on trade across the EU27 in general*. Rationally, one would *ex ante* expect the imperfect information reduction and competition enhancing effect of the Euro to dominate and hence yield increases in trade flows. However, after accounting for country pair specific effects, *id est* between country relationships can influence both Euro membership as well as bilateral trade flows (take for instance historical ties), the remaining effect of the Euro is generally insignificant as already highly integrated countries experience minimal benefits of Euro membership.

III. Methodology and Data

Part I: The Structural Gravity Model

As has been touched upon in the preceding literature review, an increasingly stronger emphasis has been placed on the consistent estimation of the effect that the national borders and currency unions have on trade[10]. In order to provide estimates that attain a similar degree of accuracy, this paper will exclusively resort to gravity models that accommodate the theoretical and econometric advances that have been made within the gravity modelling literature. To that end, this study resorts to the set of gravity models that can be derived from a wide variety of micro-economically motivated trade models, which have come to be known as structural gravity models (Arkolakis et al., 2012; Head & Mayer, 2014). Mathematically, these type of models can be expressed as a family of models for which:

$$X_{ij,t} = G_t S_{i,t} M_{j,t} \phi_{ij,t} \text{ with } S_{i,t} = Y_{i,t}/\Omega_{i,t} \text{ and } M_{j,t} = E_{j,t}/\Psi_{j,t}\, \eta_{ij,t} \qquad (1)^{11}$$

Where at time t, $X_{ij,t}$ represents the trade flow from region i to j (measured in nominal terms); $Y_{i,t}$ and $E_{j,t}$ reflect the total value of production in region i and expenditure by region j, respectively; $\Omega_{i,t}$ and $\Psi_{j,t}$ denote the multilateral resistance terms that respectively capture region i's ease of exporting to j and region j's ease of importing from i relative to all other regions (Yotov et al., 2016); and where $\phi_{ij,t}$ reflects the bilateral accessibility of region j to i (Head and Mayer, 2014). As has been hypothesised in the literature review, it is expected that a border limits this accessibility to a considerable degree and thus serves to decrease $\phi_{ij,t}$ and thus the trade flow between regions i and j that are separated by a national border. Analogously, assuming that the Euro has had a negligible effect on trade would imply

[10] This is a conclusion that is also arrived at by Havranek and Irsova (2017) with respect to the border effect literature in specific, as they conducted a meta-study into the border effect literature.

[11] Note that an additional requirement for a gravity model to be considered 'structural' is the fact that: $\Omega_{i,t} \equiv \sum_{\ell} \left(\phi_{\ell j,t} E_{\ell,t}\right)/\Psi_{\ell,t}$ and that $\Psi_{j,t} \equiv \sum_{\ell} \left(\phi_{i\ell,t} Y_{\ell,t}\right)/\Omega_{\ell,t}$, where ℓ represents the set of all regions. Moreover, note that both Arkolakis et al. (2012) and Head and Mayer (2014) do *not* derive these equations under the assumption of $T > 1$ (where T is the total number of time periods). However, it is common practice (see for instance Bergstrand et al. (2015) and Yotov et al. (2016)) to just add the subscripts t to the variables and assume that the models derived in the cross-section extend easily to multiple periods. It is however important to realise that Head and Mayer (2014) have already noted that there might be some troublesome dynamic effects that would impede such a easy extension of gravity models. Nonetheless, I will adhere to this common practice and akin to Head and Mayer (2014) refer this to avenues for future research.

that the Euro did not serve to effectively increase bilateral accessibility ($\phi_{ij,t}$) between Euro area members.

In order to be able to quantify these hypothesised effects on trade however, it is necessary to explicitly define $\phi_{ij,t}$ in terms of variables that are likely to influence this bilateral accessibility term (Feenstra, 2016). The theory underlying this type of gravity models suggest that $\phi_{ij,t}$ can generally be expressed as $\phi_{ij,t} = \tau_{ij,t}^{\varepsilon}$, where $\tau_{ij,t}$ is the trade cost function[12] and where ε[13] is either a function of the preference or productivity dispersion parameter, or of the elasticity of substitution (Head & Mayer, 2014). Theory does unfortunately not indicate how this trade cost function $\tau_{ij,t}$ is defined, and as such I will follow the common practice in gravity modelling and assume that $\tau_{ij,t}$ can be written as $\tau_{ij,t} = \exp[f(\boldsymbol{y}_{ij,t}) + g(\boldsymbol{z}_{ij,t})]$ (Yotov et al., 2016). Here, f and g are both defined as linear functions over their respective sets of variables, $\boldsymbol{y}_{ij,t}$ and $\boldsymbol{z}_{ij,t}$, where $\boldsymbol{y}_{ij,t}$ denotes the set of variables that are assumed to influence $\tau_{ij,t}$ and are of interest to this study, and where $\boldsymbol{z}_{ij,t}$ denotes the set of (standard) gravity control variables in order to permit the proper estimation of f.

In this particular study, the set of variables that are of interest ($\boldsymbol{y}_{ij,t}$) pertain to those that would permit the measurement of border effects and those that permit the quantification of the Euro's effect on trade. To that end, $\boldsymbol{y}_{ij,t}$ will include a set of intranational dummies $\delta_{ij,t}$ (with γ_t as coefficients) for all time periods t to measure the national border effect. These dummies $\delta_{ij,t}$ take the value of unity if trade between i and j does not require crossing a national border in period t and zero otherwise. In addition, this study augments the set $\boldsymbol{y}_{ij,t}$ with the dummies $Euro_{ij,t}$ that reflect whether regions i and j were both in the Euro area at time t in order to measure the effect that the Euro has had on trade. Naturally, the effect of the Euro might not have been instantaneous and for that reason I also permit for lagged terms of $Euro_{ij,t}$ to capture potential phase-in effects as has been common in the economic integration agreement literature (Bergstrand et al., 2015). In short, the function f for the purpose of this study can thus be expressed as:

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[12] The trade cost function $\tau_{ij,t}$ represents the mark-up between the 'factory gate' price $p_{ii,t}$ and the price charged to consumers in region j ($p_{ij,t}$), such that $p_{ij,t} = p_{ii,t}\tau_{ij,t}$.

[13] The factor ε is generally $(1-\sigma)$ in models that rely on homogenous consumer preferences based on CES utility functions whilst it is the productivity dispersion parameter (θ) in the Eaton-Kortum (EK) (2002) model and other supply side oriented models of trade that allow for heterogeneity in production (see also Melitz (2003)). Note that $\varepsilon < 0$ as $\varepsilon = 1 - \sigma < 0$ (a conventional assumption is that $\sigma > 1$) and that for other models with dispersion measures $\varepsilon = -\theta < 0$ (as $\theta > 0$).

$$f(\boldsymbol{y}_{ij,t}) = \gamma_t \delta_{ij,t} + \sum_{n=0}^{m} \beta_n Euro_{ij,t-n} \qquad (2)$$

However, in order to obtain unbiased and consistent estimates of the set of coefficients γ_t and parameters β_n, it is essential to control for the variables $\boldsymbol{z}_{ij,t}$ that are related to either $\delta_{ij,t}$ or $Euro_{ij,t}$ as well as $\tau_{ij,t}$. To that end, $\boldsymbol{z}_{ij,t}$ includes common gravity control variables that capture the log of distance ($\ln d_{ij}$), adjacency (adj_{ij}) and the existence of a common language ($lang_{ij}$) between region i and j (Yotov et al., 2016), which prevent biasing[14] the border effect parameters γ_t[15]. Furthermore, this study also includes dummies that reflect whether both regions were members in the EU at time t ($EU_{ij,t}$) to avoid the Euro effect coefficients β_n from accidentally picking up on the effect that entering the EU has had on EU12 members. Besides these traditional variables (see Yotov et al., 2016; Feenstra, 2016), $\boldsymbol{z}_{ij,t}$ will also include controls in the form of regional border dummies $\vartheta_{ij,t}$ (defined analogous to $\delta_{ij,t}$) for the intraregional trade, as Novy and Coughlin (2016) validly argue that not accounting for the existence of regional borders would *de facto* lead the border effects to be measured under the assumption that domestic markets are perfectly integrated[16, 17].

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[14] In specific, adjacency controls for additional expenditures falling on neighbouring regions that might otherwise be partly captured by $\delta_{ij,t}$, but that are not inherent to a national border (for instance grocery shopping in another country). On a similar note, I include $lang_{ij}$ which is also closely aligned with borders, but which would otherwise also be partly absorbed by $\delta_{ij,t}$. In addition, distance (d_{ij}) is included as trade tends to become less frequent and hence become smaller in size as distance increases. As regions of the same country tend to be in close proximity to each other, omitting distance (or mismeasurement thereof) would thus gravely distort a borders effect as it starts to partly incorporate the effect of distance, which has also been documented by amongst others Head and Mayer (2002). Furthermore, I will take the log of distance to reflect the fact that $\partial\tau_{ij,t}/\partial d_{ij} < 1$ (see also Feenstra, 2016).

[15] One could argue that the trade cost function should also incorporate factors such as tariffs in order to purify the border effect from evident border barriers. The reason that this specification does not include any tariff terms stems from the fact I will later also include importer specific fixed effects. As all EU27 countries (except for Lithuania who entered in 2001) were members of the WTO prior to the year 2000, it stands to reason that countries prior to their EU accession would levy uniform MFN tariffs on the other EU27 countries. As such, this would naturally be absorbed by the importer specific fixed effects.

[16] Whilst this poses a seemingly innocuous assumption, regional or domestic border effects have been shown to be in excess of 5 in magnitude for the US (Novy & Coughlin, 2012), with some regional border effect estimates as high as national border effect estimates for the EU (*id est* in excess of 10). Not accounting for these effects would lead border effects to be biased as the national border dummies would not *fully* incorporate to what extent border effects might already have been present at the regional level.

[17] Whilst not of particular interest to the analysis (as linearity of g would have implied as much), $g(\boldsymbol{z}_{ij,t})$ can thus be expressed as $g(\boldsymbol{z}_{ij,t}) = \rho_t \vartheta_{ij,t} + \zeta_1 adj_{ij} + \zeta_2 lang_{ij} + \zeta_3 \ln(d_{ij}) + \sum_{n=0}^{m} \xi_n EU_{ij,t-n}$

In order to now operationalise equation (1), given the specification of $\tau_{ij,t}$, I insert equation (2) into the trade cost function $\tau_{ij,t}$, consecutively substitute $\tau_{ij,t}^{\varepsilon}$ for $\phi_{ij,t}$ and subsequently log linearize equation (1) in order for it to be estimable by OLS. Additionally, I also include importer-time (α_{jt}), exporter-time (α_{it}) and time (α_t) fixed effects to appropriately control for the multilateral resistance terms $\Omega_{i,t}$ and $\Psi_{j,t}$ and the production and expenditure terms $Y_{i,t}$ and $E_{j,t}$ as has been argued by Feenstra (2002; 2016) for the cross-section and recommended by both Yotov et al. (2016) and Bergstrand et al. (2015) for panel data. I resort to these fixed effects as computing the multilateral resistance terms would be computationally very intensive and require more stringent assumptions with regard to the underlying theoretical model that gives rise to the structural gravity equation[18]. Hence, the econometric specification used by this study to assess border and currency union effects can be expressed as:

$$\ln X_{ij,t} = \alpha_t + \alpha_{it} + \alpha_{jt} + \varepsilon\gamma_t\delta_{ij,t} + \sum_{n=0}^{m} \varepsilon\beta_n Euro_{ij,t-n} + \varepsilon g(\mathbf{z}_{ij,t}) \qquad (3)$$

For which it can be easily shown that $\varepsilon\gamma_t$ exponentiated yields the border effect level at time t and where $\sum_{n=0}^{m}\varepsilon\beta_n$ exponentiated yields the percentual increase in trade between members of the Euro area due to the introduction of the Euro[19]. However, whilst the border effect *level* can be validly inferred from estimating equation (3), there are two problems that arise when trying to assess the change in border effects and the Euro's impact on trade. The first problem that arises concerns

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[18] See for instance Anderson and van Wincoop (2003) who use custom programmed iterative least squares (SILS) to compute the multilateral resistance terms. As the usage of fixed effects also allows for consistent, albeit less efficient when the underlying data generating process is truly given by the presumed theoretical model used to derive the gravity equation, estimation of both border and currency union effects, I resort to gravity models that include importer-time, exporter-time and year fixed effects which have been popular throughout the literature (Feenstra, 2002; Feenstra, 2016).

[19] To see this, raise the trade cost function to the power ε:

$$\phi_{ij,t} = \exp\left[\varepsilon\gamma_t\delta_{ij,t} + \varepsilon\sum_{n=0}^{m}\beta_n Euro_{ij,t-n} + g(\mathbf{z}_{ij,t})\right] = e^{\varepsilon\gamma_t\delta_{ij,t}}e^{\varepsilon\sum_{n=0}^{m}\beta_n Euro_{ij,t-n}}\, e^{\varepsilon g(\mathbf{z}_{ij,t})}$$

Subsequently presume that there are two regions k and j to which i exports, where k and j are similar in every respect (also the in their distance from i), except for the fact that k is separated from i by a national border. Now divide $X_{ik,t}$ by $X_{ij,t}$ to obtain:

$$X_{ik,t}/X_{ij,t} = GS_iM_je^{\varepsilon\gamma_t\delta_{ij,t}}e^{\varepsilon\sum_{n=0}^{m}\beta_n Euro_{ij,t-n}}\, e^{\varepsilon g(\mathbf{z}_{ij,t})} \Big/ GS_iM_ke^{\varepsilon\gamma_t\delta_{ik,t}}e^{\varepsilon\sum_{n=0}^{m}\beta_n Euro_{ik,t-n}}\, e^{\varepsilon g(\mathbf{z}_{ik,t})} = e^{\varepsilon\gamma_t}$$

Hence, $\varepsilon\gamma_t$ exponentiated yields the border effect in terms of how much more trade a region conducts with another region that is within the same nation as opposed to a region across the border. A similar line of reasoning can be used for the Euro dummy which exponentiated yields the percentage increase in trade due to the introduction of the Euro.

the fact that border effects might be heterogenous across nations, which would potentially obfuscate changes as it places relatively more weight on high border effect countries (Bergstrand et al., 2015). The second problem stems from the potential self-selection into the Euro by countries based on factors such as historical ties, which might additionally have also influenced the level of trade between both countries. To account for both issues, I will also augment equation (3) with region-pair specific (dyadic) fixed effects (α_{ij}) following Yotov et al. (2016) and Bergstrand et al. (2015). To see how this resolves both problems, note that it absorbs the initial (heterogenous) level of border effects in the year 2000 when dropping $\delta_{ij,2000}$, which changes the parameters $\varepsilon\gamma_t$ from reflecting absolute levels into *changes* relative to the year 2000. In addition, including α_{ij} also accounts for time-invariant factors such as historical ties that might have influenced both a country's propensity to become a member of the Eurozone and trade more with other Eurozone members.

Part II: Additional Methodological Considerations

As the structural gravity model could now in principle be estimated as equation (3) using OLS, there are three remaining, yet not unimportant, 'loose ends' that need to be addressed. The first of these loose ends pertains to the question of whether equation (3) should be estimated over intervals or over consecutive years. Cheng and Wall (2005) have argued that estimating gravity models over consecutive years might not allow the multilateral resistance terms, as well as regional production and expenditure, to adequately adjust to changes in the trade cost variables, and as such it would cause coefficients to improperly reflect the true effect of for instance currency unions and national borders on trade. Following Baier and Bergstrand (2007), this study will estimate equation (3) over interval data of 5 years to allow for those variables to adjust. As a fortunate coincidence, this automatically resolves the second loose end which pertains to the lag length selection of the Euro dummy. The 5 year interval data only allow for lags of either 5 years or 10 years, and as the Euro was only introduced in 2002, lags equal to 10 years or higher would logically be collinear[20]. As such, all specifications include 5 year lags of the Euro and the EU dummies.

The last remaining loose end relates to the estimation technique used to obtain parameter estimates. Equation (3) could be estimated by OLS, but there are

[20] Using the ingenious solution used by Bergstrand et al. (2015), I appended data on whether countries had the Euro as their official currency before 2000 back till 1995. As such, I can still use lags of the Euro without having to 'sacrifice' any time periods since the year 2000. The lag length cannot be extended to 2 (i.e. 10 years) as the Euro was only introduced to the public in 2002, and therefore a second lag would automatically be equal to 0 and hence be collinear.

two prominent objections to doing so. Firstly, estimating equation (3) in log-linearized form could be problematic as the log-linearization could *de facto* have censured the trade data by eliminating all observations that are zero, effectively introducing selection bias (Feenstra, 2016). Secondly, the fact that errors of most gravity models in the literature have been plagued with heteroskedasticity would imply that using OLS would yield biased results, as argued by Santos Silva and Tenreyro (2006)[21]. Fortunately, the multiplicative nature of the gravity model and the additivity of variables within the exponentiation operator on the right hand side of equation (3) allow for the estimation of the structural gravity model using Pseudo Poisson Maximum Likelihood (PPML), which in contrast to OLS does not require $X_{ij,t}$ to be transformed using the log transformation and appropriately deals with heteroskedasticity in trade data (Santos Silva and Tenreyro, 2006). Hence, this paper will estimate equation (3) by resorting to PPML instead of OLS.

Part III: Data Requirements

In order to be able to estimate equation (3) for the EU according to the econometric specifications mentioned above, it is essential to have regionalised trade data for the EU27 ($X_{ij,t}$). Using a unique set of regionalised input-output tables (EUREGIO) as estimated by Thissen et al. (2018) for the EU27 over the period 2000-2010, I compute the regional trade flows between all 252 NUTS2 regions[22] by 14 distinct sectors and subsequently aggregate trade flows by goods and services. Thissen et al. (2018) compiled the EUREGIO database by resorting to the WIOD supply-and-use tables and consecutively regionalised these tables (after correcting for re-exports and ensuring that exports and imports are mutually consistent) by using regional data on production and consumption in addition to the PBL regionalised trade dataset for the year 2000[23]. Intraregional trade flows $X_{ii,t}$, which are required when including the set of regional border effect dummies ($\vartheta_{ij,t}$), have been computed by obtaining the exports of sector k to all domestic sectors as well as to domestic final demand and

[21] See also Feenstra (2016) for an excellent discussion on how heteroskedasticity might arise and why it might bias the parameters on *all* variables in the trade cost function.

[22] NUTS regions (Nomenclature of Territorial Units for Statistics) is the classification system for regions within the EU. The different levels refer to different scales, as NUTS1 regions refer to regions with populations between the 3 and 7 million inhabitants whilst NUTS2 consists out of regions that consist out of 800 thousand to 3 million people. Most NUTS regions correspond to administrative divisions as used by the EU member states (European Commission, 2019a).

[23] See the paper by Thissen et al. (2018) for an in depth discussion of the regionalisation of the WIOD supply and use tables and the consecutive derivation of the regional Input-Output tables. Note that the regionalised tables are consistent with the WIOD supply and use tables.

subsequently aggregating over k to obtain total intranational trade, which is relatively similar to the approximation used by Wei (1996)[24].

In addition, all variables in $\boldsymbol{z}_{ij,t}$ also need to be included when assessing the national border's and the Euro's effect on trade. Unfortunately, neither the distance matrix between all NUTS2 regions (including d_{ii}) nor the adjacency matrix were readily available at this level of geographical aggregation, and as such these matrices had to be constructed in order to be able to conduct this study. As noted by Head and Mayer (2000), Mika (2017) and Havranek and Irsova (2017), it is of crucial importance that the distances within NUTS2 regions, as well as between them, are consistently measured for the proper assessment of both regional and national border effects. In order to compute these consistent distances, I follow Head and Mayer (2000; 2002) in using distance on a lower level of aggregation (in this case NUTS3) and weigh the distances to obtain an 'average' distance for the higher level of spatial aggregation. This is equivalent to stating that:

$$d_{ij} = \sum_{k \in i} w_k \sum_{l \in j} w_l d_{kl} \qquad (4)$$

where d_{kl} is the distance from NUTS3 region k within NUTS2 region i to NUTS3 region l within NUTS2 region j and where w_l and w_k are the destination and origin weights, respectively. These weights are computed using employment data for the origin weights and GDP data (both obtained from Eurostat) for the destination weights. Unfortunately, GDP and employment were not available for every region prior to the year 2000 and for that reason I used a regional fixed effects estimator with regional fixed effects terms interacted with the time trend to linearly extrapolate GDP and employment back to 2000. An exception to this practice was made when either GDP or employment data were not available prior to 2008, as the great recession would probably have marked a break in the time trend. For those regions, primarily in France, the Netherlands and Poland, this study resorts to the more readily available symmetric origin and destination weights based on the total population of a NUTS3

[24] Note that this does *not* reintroduce the same problems encountered by national-level based studies. The only parameter that could potentially be affected by (for instance) geographical clustering is now the set of coefficients on $\vartheta_{ij,t}$. However, as the objective of this paper has been identifying the *national* level border effects, it just serves as a control variable (*id est* the exact impact of regional borders on trade is of no importance to this study). In addition, this variable will capture geographical clustering at a lower level of aggregation, which might subsequently be used to support the reasoning that one needs regional(-ised) trade flow data as the effects measured would reflect similar effects to those estimated by Novy and Coughlin (2012) and Wolf (2000).

region, as also used by Head and Mayer (2002). The distance between the NUTS3 regions (d_{kl}) (both road and airport/great circle distances) were obtained from the TERCET database of Eurostat[25]. Throughout this study, I will resort to great circle (or airport) distances and provide robustness checks for road distances to facilitate comparisons with recent studies that use road distances (see for instance Braconier and Pisu (2013)). For more elaboration on the exact technical details of the construction of these distance measures, I will refer the readership to appendix B.

Analogous to the distance matrix that did not yet exist, the adjacency matrix between all NUTS2 regions of the EU27 also needed to be constructed for equation (3) to be estimable. To that end, I consulted all the NUTS2 maps across the EU27 by country, as well as the general EU27 NUTS2 map, to determine whether a pair of NUTS2 regions shared a common land border or bridge/tunnel. These maps where also retrieved from Eurostat. For other variables that denote whether both region i and j had the Euro as their official currency (*id est* introduced the Euro to the public as banknotes or coins) as well as whether both regions belonged to the EU, I have consulted the website of the EU, the European Commission and the European Central Bank. Common language has been obtained by consulting research papers conducted by the EU that reported the first and three other primary spoken languages. From this information I created the national common language matrices that reflected whether a pair of countries had the same native language, whether they both spoke English, the same native language or a third in common language such as Russian for the Baltic states as classified by Directorate-General for Translation (2013) and TNS Opinion & Social (2012)[26].

Part IV: Descriptive Statistics

The descriptive statistics provided in appendix C reveal that both trade in goods and services are characterised by high standard deviations in trade as well as a

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[25] Note that the TERCET database has become available only recently (2018) and hence it used the NUTS2 classification as of 2016 which had some minor changes compared to the NUTS2 regions in 2013. However, the NUTS used by the PBL were largely consistent with the NUTS 2010 version with the exception of Denmark where the PBL adopted a more granular NUTS division ('West of the great bridge' instead of the 3 NUTS2 regions that actually existed according to the NUTS2010 version. Hence, this required the me to construct crosswalks between the NUTS2016 and NUTS2010 and NUTSPBL, which was only problematic the Brandenburg (DE41 and DE42) as well as a region in Finland and for Northern Ireland in its entirety. To that end, distance between other NUTS3 regions were considered unreliable which led me to omit those regions from the analysis.

[26] As this study uses a multitude of sources, appendix A displays a list of all variables, and their respective sources can be found with a corresponding link to the database interface or paper.

considerably smaller median compared to its mean across the EU27 for all periods (2000, 2005 and 2010). It is this implied skewness in conjunction with the fact that the mean and median are noticeably larger when considering exclusively intranational trade flows as opposed to international trade flows, that presents a strong indication of the presence of prominent national border effects. Furthermore, the relationship between the means (and medians) between intra- and international trade flows for services relative to that of goods, seem to reveal that intranational trade is much larger for services relative to international trade than for goods for both the EU15 and EU12. This would *ex ante* strengthen the belief that services are indeed less integrated than trade in goods as documented by Mika (2017). Nonetheless, there may be other factors causing these relative differences between intra- and international trade flows besides national borders, such as distance, prices and adjacency. Hence, this simple observation is not sufficient to state whether there is indeed disproportionately more trade within countries compared to between countries, and as such a formal analysis will follow using the methodology outlined in the first two parts of this section[27].

IV. Results

Part I: Border effects in the EU27's goods market

In spite of the fact that the descriptive statistics and the academic literature seemed to both indicate the presence of prominent border effects throughout the European Union, the border effects estimated using equation (3) and PPML without dyadic fixed effects over both yearly and interval data[28] (specifications 1-2 in table 4) imply a much higher level of integration in goods trade compared to previous studies (Martínez San Román et al., 2012; Cheptea, 2013; Mika, 2017). The goods markets of

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[27] Note that these tables do not display the log of trade and hence do not reveal the frequency of zeros in trade which was one of the primary reasons to use PPML. Aggregated by goods or services, it seems that the dataset contains a limited amount of zero trade flows (sometimes not more than a few hundred, see discrepancies in observations between PPML and OLS estimation in appendix E) which was probably caused by the regionalisation procedure minimising its error (i.e. zero trade flows were given a small yet not zero value). It is important to keep in mind however that more than 10% of the observations in goods trade are beneath the 500,000 EUR and slightly less than 25% of the observations for trade in services in 2010. The existence of such variety in trade flow size might exacerbate heteroskedasticity instead, which would still cause OLS to yield biased results whilst PPML should be consistent. See footnote 26. For the reasoning behind this see for instance Feenstra (2016) or Santos Silva and Tenreyro (2006)).

[28] Note that using yearly or interval data does not severely impact the estimated border coefficients and therefore I will mainly refer to the interval estimations as these have been the standard in panel data gravity modelling (see for instance Yotov et al. (2016) and Bergstrand et al. (2015)). Note however that I resorted to yearly data though for the construction of figures 1 and 2.

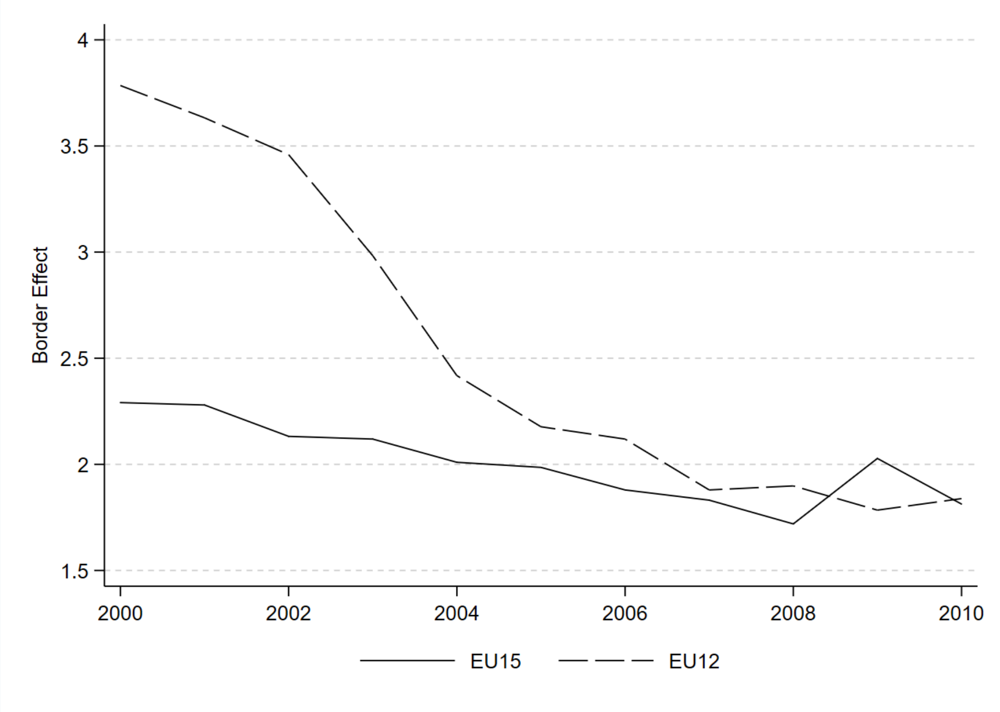

Figure 1: National Border Effects in the Goods Market for both the EU15 and the EU12. These estimates have been obtained from specification 1 in table 4, which estimates equation (3) using PPML over yearly data.

both the EU15 and EU12 are characterized by border effects of around 2 (exp[0.852]) and 4 (exp[1.358]) at the beginning of the 2000s, respectively. This implies that EU15 (EU12) regions traded on average only 2 (4) times more with another region within the same country as opposed to a similar region in size and distance belonging to a different EU27 country in the year 2000. As can also be seen from the figure 1 above, the border effect within both the EU12 and EU15 have furthermore been in decline over the period 2000-2010, only increasing slightly for the EU15 during the financial crisis of 2009, as has also been noted by Mika (2017). Remarkably, the EU12 seems to have converged at EU15 levels of economic integration by 2010 for trade in goods, achieving an average border effect of around 2 as well.

In particular, the pooled EU27 structural gravity model (table 6 specifications 1-2) finds no significant difference between the EU12 and EU15 border effect levels for both the yearly and interval data specifications since the year 2005 (see national border effects interacted with a dummy that reflects whether it concerns a EU12 country or not[29]). This convergence between EU15 and EU12 levels of

[29] Note that one could infer EU12 border effects from the pooled model by adding the Home National 2000 (reflecting $\varepsilon\gamma_{2000}$) to the Home National EU12 coefficient (reflecting $\varepsilon\gamma_{2000} * 1\{EU12\}$). Note furthermore that these are not completely additive, *id est* they do not exactly add up to the coefficients reported by the non-pooled estimations by EU12 and EU15. The coefficient estimates might be slightly different, but there exists no reason to belief that the estimates are widely different when taking confidence intervals into account.

economic integration in goods trade, has been the product of the rapid decline of border effects experienced by EU12 countries during the first 5 years of the estimation period (see figure 1). Specification 3, with dyadic fixed effects in table 4, shows that border effects have significantly declined over the period 2000-2010 by ~19% (1 − exp[-0.205]) for the EU15 and by ~40% (1 − exp[-0.479]) for the EU12[30]. Note furthermore that the significance of the border effect for both the EU15 and EU12 have been declining over the period 2000-2010 as well, indicating that border effects are further eroding to the point where these are nearly indistinguishable from zero, which would imply no effective border barriers between EU27 members states exist, as had been expected for the EC by Wei in 1996.

A remarkable, yet expected, finding arises when one turns to the home regional dummies ($\vartheta_{ij,t}$). These dummies seem to indicate stunningly high and significant regional border effects of magnitudes around the 8 for the EU15 and around the 10 for EU12. As has also been argued by Wolf (2000) for the US, most regional borders within countries can however not erect such high border barriers as national legislation prevents individual regions from doing so. As the regional border effects are reminiscent of Novy and Coughlin's (2012) results for the US as well, where regional border were accredited to vertically integrated firms clustering together geospatially, I perceive this as evidence of such a similar level of clustering of firms for the EU27 (for both the EU12 and EU15). This is in line with findings of Chen (2004) for the EU as well, who documents that geospatial clustering might also have contributed to European national border effects. It is remarkable, perhaps considered a slight coincidence, that adding these regional border effects to the documented national border effects in this study yields 'total (mixed) border effects' which are around 10 and 13 for the EU15 and EU12, respectively. These 'total (mixed) border effects' are surprisingly similar in size to those documented by Mika (2017) and Cheptea (2013). At the risk of speculation, I further argue that these results might additionally provide some evidence, though not formally, for Head and Mayer's

[30] It is important to see that also the dyadic fixed effects estimation implicitly provides a robustness check to the non-dyadic fixed effects estimations. It is not expected that the change implied by the dyadic fixed effects reveals a completely different pattern to the border effect coefficients in the other specifications. To see how these estimates can be compared, one could simply subtract the coefficient on Home National dummy ($\delta_{ij,t}$) in year t of the dyadic fixed effects specification from the Home National 2000 coefficient in the other specifications. One should then roughly obtain the estimate for Home National at time t for the non-dyadic fixed effects specification. All dyadic specifications in tables 1-3 seem to imply that this is in fact the case, strengthening the robustness of these results.

(2013) notion that national border effects might be driven by isolation legacy effects.[31] This would imply a certain degree of persistent home bias, which would thus imply that national border effects would only decline slowly over time as has been documented by this study for the EU15.

I conclude, with respect to trade in goods, that the hypothesis that *the average national border effect for trade in goods has remained around 10 in magnitude by 2010* can be readily refuted as coefficients for 2010 for the EU12 and EU15 are not even remotely close to 2.3 (*id est* exp[2.3]=10) in magnitude. This implies that the found border effect estimates are remarkably smaller than those found by national-level trade data based studies by Cafiso (2011), Martínez San Román et al. (2012), Cheptea (20130 and Mika (2017). The other hypothesis that evaluates the change in border effects for the EU12 (*national border effects for trade in goods and services have significantly decreased over the period 2000-2010 for the EU12*) cannot on the other hand be readily rejected for trade in goods. It is logical that this study finds a similar tendency of border effects over time to the aforementioned studies, as the clustering of firms forms a persistent basis for 'mixed' border effects[32]. Hence, this might indicate that national-level based studies might seemingly still be able to adequately capture *changes* in border effects, whilst unable to capture its true magnitude. The hypothesis for the EU15, where no significant change over time was expected for the national border effects, can however be rejected for EU15 goods trade. The reason why this differs from Cheptea's (2013) and Mika's (2017) trend, is probably owed to the fact that this study has more power to distinguish this development as the sample size used in this study is vaster.[33]

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[31] Isolation legacy effects refer, amongst others, to the fact that historical isolation by national borders have fostered localised tastes as has been described by Grossman (1998). As a result, border effects are relatively high, but preferences only change slowly. As such, border effects are expected to only diminish slowly over time as well when it is considered a main driver behind the existence border effects.

[32] Note that regional border effects, contrary to national border effects, do *not* seem to decrease over time. This lends further support to the idea that it in fact is the clustering of firms causing these high regional border effects as one would expect firm allocation to be relatively stationary across time.

[33] Note that these findings appear to be robust to alternative distance specifications as shown in table 7 (where 'interval' distances refer to a step-function for every 500 km as the distance metric $\ln(d_{ij,t})$ is then replaced by a more flexible functional form). Throughout the results section preference is given to the PPML estimator instead of the OLS estimator. The OLS estimates have been provided in the tables 7 and 8 as a reference point. The primary reason for this stems from the fact that the OLS estimator yields negative coefficient estimates on the adjacency dummy, which is also encountered by Cheng and Wall (2005) who attribute this to heteroskedasticity on the error term. In a similar fashion, Cheptea (2013) also ascribes widely different coefficients by PPML and OLS to heteroskedasticity in the error

A surprising disparity between EU12 and EU15 countries however arises when assessing the border effects in service trade. The EU15 countries exhibit, as expected, high border effects in service trade that are in magnitude around the 22 (exp[3.107]), which reflect the higher national border frictions that arise in service trade. This aligns with the findings by both Mika (2017) and Liu, Whalley and Xin (2010) that border effects in service trade are considerably larger than those for goods trade. Supporting this notion that service trade has been markedly less integrated even further, is the fact that the European Commission has continuously endeavoured to especially standardise services across the EU as to enhance economic integration (European Commission, 2019b). On the other hand, when assessing the EU12's level of economic integration through its national border effects, it is clear that the EU12 has been considerably *more* integrated compared to the EU15. In particular, the EU12's border effects in service trade are to a large extent comparable in magnitude to those of trade in goods, with average border effects around the 2.5 (exp[0.923]). Whilst obvious explanations are not readily available, I will resort to theory to argue why these border effects might be so different for the EU15 as opposed to the EU12.

Note that the coefficient on the border dummy reflects not only the specific impact of the border (γ_t) on trade and the trade costs $\tau_{ij,t}$, but it also reflects ε. Lets presume, following Anderson and van Wincoop (2003), that the underlying data generating process can be accurately described by a representative consumer that maximises its CES utility function under the constraint that the total value of production of a country equals its total expenditure on domestic and foreign goods. In addition, let us assume that every country only produces one service. In that case, ε can be defined as $\varepsilon = (1 - \sigma)$, where σ is the elasticity of substitution between both domestic and foreign services. Note, that if the services are highly substitutable, *id est* σ is relatively large, the border effect will be more pronounced, as the border's impact on trade costs will increase the price charged to foreign consumers through the trade cost function $\tau_{ij,t}$ and hence lead these consumers towards consuming regional substitutes instead. If regional services are largely complementary in nature though, σ will be relatively small, and as a result the borders effect will be less pronounced as

term and therefor resorts to PPML based estimates. Unfortunately, the RAMSEY Reset test is unavailable as a post-estimation command after *ppmlhdfe* and *reghdfe*, I will not endeavour to provide additional substantiation for this claim but rely on the literature to justify my belief that the OLS model is biased and inconsistent due to heteroskedasticity as shown by Santos Silva and Tenreyro (2006).

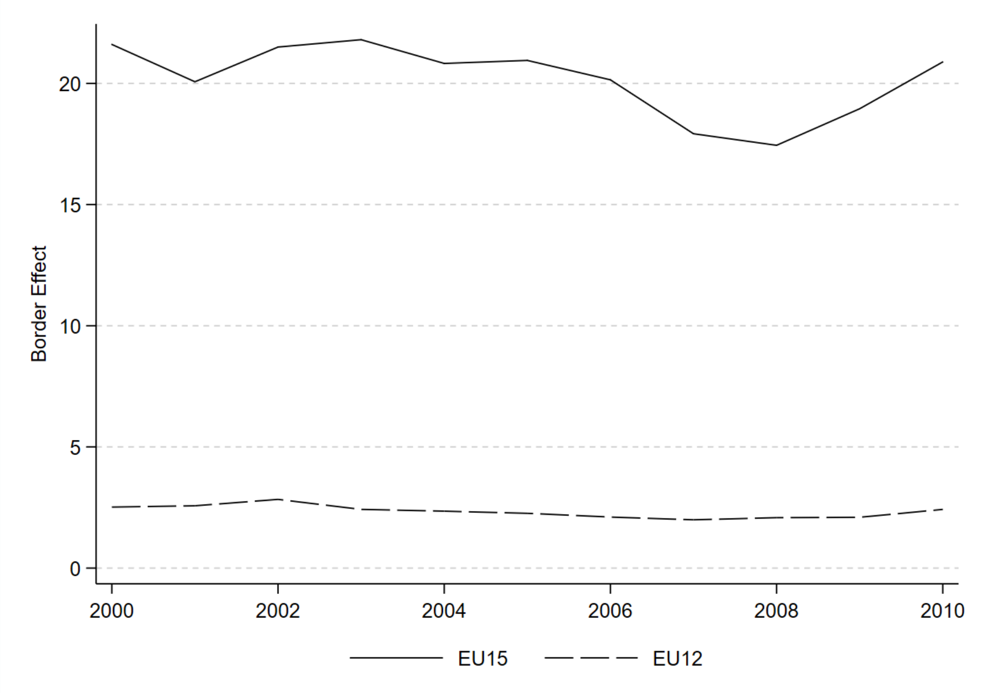

Figure 2: National Border Effects in the Service Market for both the EU15 and the EU12. These estimates have been obtained from specification 1 in table 5, which estimates equation (3) using PPML over yearly data.

consumers will persist by increasing their relative expenditure on such goods (that is if $\sigma < 1$)[34]. It could be plausible that the EU12 countries have more complementary service sectors, especially within the EU12, as the planned economy during the Soviet era (to which most of the EU12 countries belonged) could potentially have fostered such inter-regional-dependence. EU15 countries remained however independent during that era and probably created highly similar industries across national borders.

Leaving this apparent, yet fascinating, discrepancy aside, both the EU12 and the EU15 see no significant and strong decline in their national border effects for trade in services over the period 2000-2010. This could provide perhaps even stronger, albeit circumstantial, evidence of Head and Mayer's (2013) hypothesis that border effects are persistent due to home bias and erode only slowly over time. In addition, I document that regional border effects in service trade ($\vartheta_{ij,t}$) are even more staggering compared to those for trade in goods, which are on average around the 56 (!) and 32 (!) in magnitude for the EU15 and EU12, respectively. Similar to the argument followed for goods trade, this apparently signifies spatial clustering of service firms as well, which is instead more likely to be oriented towards settling near

[34] Note that this could be the case if one region is predominantly specialised in construction whilst another region at the other side of the national border is specialised in for instance financial services. This pattern would generally not arise naturally, but a planned economy as during the soviet era (to which most of the EU12 countries belonged) could have generated such a 'complementary' structure of service sectors across national borders in an attempt to unify Eastern Europe (*id est* the EU12).

their consumers instead of their suppliers as opposed to goods trade. Nonetheless, this offers an even more compelling reason to use regional-level trade data as estimating border effects using national-level trade data for services would thus overstate the impact of the national border to an extremely large degree.

I conclude, with respect to trade in services, that the hypothesis that *the average national border effect for trade in services has been larger than 10 in magnitude by 2010* can be readily refuted for the EU12, as its border effect coefficients differs significantly from 2.3 by 2010. It is however important to note that this hypothesis cannot be rejected for the EU15 as it exhibits significantly higher national border effects than 10. Whilst the latter is in line with Mika's (2017) findings that service trade has been considerably more fragmented as compared to goods trade, the former poses a small puzzle *en sich*. I argue, whilst not supported by a rigorous statistical analysis which is left to future research, that this could have been a result of the Soviet rule during the majority of the second half of the 20th century. The other hypothesis that regards the development of border effects for the EU12 (*national border effects for trade in goods and services have significantly decreased over the period 2000-2010 for the EU12*) can be readily rejected for trade in services as the dyadic fixed effect specification does not show a significant decline. The hypothesis for the EU15 where no significant change over time was expected, can however not be rejected for EU15's service trade.

Part III: The Euro's effect on EU integration

Table 1 below provides the consolidated estimates obtained from the estimation of the structural gravity model in equation (3) using dyadic fixed effects and PPML over 5 year intervals and one corresponding lag to account for any phase-in effects that the Euro might have had on trade. Note however that the earliest EU12 member that adopted the Euro adopted the common currency in 2007 (Slovenia), and as such the lagged effect of the Euro is multicollinear as every 5-year lag is by definition equal to zero for all EU12 members. Nonetheless, the estimations in the goods panel seemingly reveal some heterogeneity in the total effect that the introduction of the Euro has had on trade amongst the EU15 and the EU12 members, despite the quantile regression results of Figueiredo, Lima and Schaur (2016) yielding no significant effect at different parts of the trade flow distribution. However, as both total effects are not significantly different from zero, I cannot dismiss the possibility that the true effect of the introduction of the Euro was in fact negligible for both the EU12 and EU15. The same pattern emerges for trade in services, and once again no results are statistically significant for the EU12 and EU15 separately.

Table 1: The Euro's Effect on Regional Trade

	Goods Trade			Service Trade		
	EU15	EU12	EU27	EU15	EU12	EU27
The Euro's Effect						
Euro	-0.074	0.175	-0.067	-0.266*	-0.225	-0.226
	(0.092)	(0.227)	(0.084)	(0.130)	(0.180)	(0.122)
Euro (t-5)	0.003		0.015	0.214		0.180
	(0.121)		(0.119)	(0.170)		(0.165)
Total Euro Effect	-0.071	0.175	-0.052	-0.052	-0.225	-0.046
p-value	0.660	0.442	0.741	0.805	0.212	0.826

Notes: this table presents an overview of the Euro's effect on trade as estimated by the set of dyadic fixed effects estimations conducted in this paper (see tables 3-6). Standard errors, clustered by country-pair following Bergstrand et al. (2015), have been provided in parentheses beneath the coefficient estimates. All specifications apply in importer-time and exporter-time fixed effects as well as year fixed effects and have been estimated using PPML and 5 year interval data. *p<0.05, **p<0.01, ***p<0.001

In contrast to the studies by Cafiso (2010) and Rose (2017), who report that the Euro has had a positive effect on trade and EU integration for Euro area members in the EU27, this study finds little evidence hereof as the total effect of the Euro on trade is even slightly negative for the EU27 in general, implying that the Euro actually seems to have decreased trade between Euro members with ~5% (1 – exp[-0.052]) for goods trade and ~4.5% (1 – exp[-0.046]) for trade in services. However, as with EU15 and EU12 trade, the total effects are both not significantly different from zero with p-values of 0.741 and 0.826, respectively. As such, the true effect could as well have been negligible. This small insignificant negative effect is in line with the findings of both Figueiredo, Lima and Schaur (2016) and Santos Silva and Tenreyro (2010). Notably though, one Euro effect coefficient is significantly negative: the 'direct' effect of the Euro on service trade for the EU15. This result does however not only stand out on the basis of its significance, but also due to the fact that it is indicative of the tendency of the direct effect, albeit that most coefficients are insignificant, of the Euro to be slightly negative, whilst the delayed effect seems to be positive, regardless of whether it concerns service or goods trade or EU12, EU15 or EU27.

This tendency could be explained if prices were to exhibit considerable downward real price rigidity and increased their prices at the introduction of the Euro such that suppliers in non-euro area countries became more attractive, leading to an initial increase in trade volumes between Euro members and non-Euro members. Note that evidence of staggering price increases around the introduction of the Euro has been documented by Hobijn, Ravenna and Tambalotti (2006). I hypothesise that as prices (slowly) adjust however, due to these menu costs, trade between Euro members reverts only slowly back to pre-Euro levels. Naturally, this analysis only includes 5 year lags as the data does not permit the inclusion of more lags, and for that reason this study cannot determine the long-run effects that the Euro might have had on trade as positive effects might accrue at a longer time horizon. The 5 year lags however seem to be generally supportive of this notion as trade indeed increases again between Euro members as time passes.

Nonetheless, this study offers a less optimistic view on the effectiveness of the adoption of the Euro on trade and economic integration. Based on the studies by Figueiredo, Lima and Schaur (2016) and Santos Silva and Tenreyro (2010), I expected that the effect of the Euro on trade and thus economic integration would have been negligible. The hypothesis that *there is no significant total effect of the Euro on trade across the EU27 in general* can in light of these results not be rejected. I usher however on the side of conservatism by also clearly stating that these are *short-run* effects of the Euro on trade, and that the Euro might have had a more pronounced positive effect on trade after a longer time period if the reasoning presented earlier is to be believed. By extension, I conclude that the Euro has thus seemingly done little to reduce trade barriers in the short run between Euro area members and hence between EU members in general.

V. Conclusion

Whilst the border puzzle has been proclaimed solved for the US-Canadian border by Anderson and van Wincoop (2003), the border effect estimates in the EU remained puzzlingly large (Cheptea, 2013; Mika, 2017) despite implementing the methodological advancements that had successfully shrunk the border effect for the US-Canadian border. This paper has argued that by addressing the main difference in study design between research into border effects for North-America and the EU, the level of geographical aggregation of trade flow data, this border puzzle can now also be solved for the EU. By using a new and unique regional (sub-national) trade flow dataset, instead of the conventional national-level based trade data that has been used for the EU as regional trade data has been extremely rare, this study re-investigates how sizeable border effects for the EU actually are and how these have changed over time. In addition, this study also revisits a traditional explanation for the border effects, differing currencies, by reassessing the influence that the introduction of the Euro has had on trade and thus on EU integration for which empirically there has been found little evidence. As such, this paper has tried to answer the question:

"How have national border effects developed across the European Single Market for goods and services over the period 2000-2010 and how has the Euro affected the European Union's economic integration?"

This study finds that the EU's internal market for goods is considerably more integrated as opposed to the findings by previous studies using national-level data. I document that European regions trade on average around 2 times more with other regions within the same country as compared to a similar region across the national border by 2010, instead of 10 (or more) times as estimated by Cafiso (2011), Martínez San Román et al. (2012), Cheptea (20130 and Mika (2017). The European market in services is, as expected, more fragmented, albeit strongly heterogeneous in its level of integration across the EU. In particular, the EU15 members exhibit considerably higher national border frictions of a magnitude of around the 22 as compared to the mere 2.5 of the EU12 in the year 2000. Across the EU, the national border effects have been in decline over the period 2000-2010 with the exception of trade in services, which has remained at a similar level of integration by 2010 as it had been in 2000. The Euro has however not appeared to increase trade, at least in the short run, between euro members and thus did not foster further economic integration within the EU27[35] as also reported by Santos Silva and Tenreyro (2010).

These results, that jointly answer the main question of this study as outlined in the previous paragraph, do however provide an additional fundamental insight for the national border effect literature. As this study also documents the existence of regional border effects for the case of the EU, analogous to the findings of Wolf (2000) and Novy and Coughlin (2012) for the US, which are likely stemming from the geospatial clustering of firms with their suppliers and (or) consumers, national-level data is *insufficient* to distinguish between national border specific effects and the effects that are inherent to regional trade as well, *id est* regional border effects. For that reason, border effect studies using exclusively national-level trade data and which subsequently infer intranational trade flows using Wei's (1996) approach, should, in general, be treated with extreme scepticism when such a study tries to account for the *level* of economic integration by estimating the magnitude of national border effects. This study shows that these studies (see for instance Cafiso (2011), Martínez San Román et al. (2012), Cheptea (20130 and Mika (2017)) consistently over-estimate the effect of national borders. Importantly, national-level based studies might on the other hand serve as a valid approach for quantifying how border effects *change*, particularly as regional border effects, and thus geospatial

[35] As has been explained in the results section part III, where the Euro's effect on trade has been discussed, the pattern in coefficients, especially the signs despite the apparent insignificance, seemingly point at a longer adjustment process of countries to the introduction of the Euro. Hence, I usher on the side of conservatism and only draw inference for the *short*-run as the time frame available (2000-2010) is simply not long enough to capture long-run effects of the Euro.

clustering of firms, seem to be persistent as no significant decline in regional border effects was observed. Perhaps as a relief to policy makers, estimation at the regional trade data level also seems to have been irrelevant to the obtained effect of the Euro compared to estimates obtained in the rest of the currency union effect literature (Santos Silva and Tenreyro, 2010).

In addition to these this important empirical implication, this study also provides room for further academic research and has policy implications. Some findings were unexpected such as the large integration disparity found in service trade within the EU12 compared to that of the EU15. Whilst an explanation for the disparity was sought in the complementarity of services in different regions across the national border for the EU12 due to Soviet rule during the majority of the second half of the 20th century, this did not rely on formal statistical analysis. As such, this discrepancy remains open to interpretation and provides a puzzling characteristic of the EU's internal market that should be better understood if the EU is to develop service integration policy. In addition, this regional-level based research also provides a strong indication that the effect of further economic integration through the introduction of the Euro has appeared to be, at least in the short-run, ineffective. For that reason, further integration on the premise that it is necessary to maintain this institution of market integration should be treated with some scepticism as the Euro does not seem to provide many trade related benefits as frequently has been presumed. Though, further research is needed with more recent data to be able to assess the effect that the Euro has had on EU12 members as well as what the long-run effects of the Euro have been on trade and economic integration.

It is however also important to keep in mind the potential caveats of this study. In general, the trade flows that are reported in EUREGIO are *estimated* using, amongst others, survey data and provide the most *likely* trade flows. In the absence of factual regional trade flows, these trade flows provide the best next alternative, but might have introduced measurement error which would have become more pronounced with fixed effects. Furthermore, this study has used PPML with origin-time, destination-time and dyadic fixed effects to account for time-invariant endogeneity associated with self-selection into the Euro as to provide accurate estimates of the Euro's effect on trade and economic integration. An alternative approach that also captures time variant factors that cause endogeneity as offered by Bergstrand et al. (2015) would be by interacting the region-pair specific effects with a time trend. As these were not included (in light of the infeasibility of easily implementing these in *ppmlhdfe* and *reghdfe*), there might still have been bias on the

Euro terms. Nonetheless, I belief that the results are relatively robust against both issues and that the border effects obtained in this study are probably accurate.

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Appendix A: Data Sources

In the list provided below, I state a variable's full name and description in addition to its associated symbol in equation (3) and subsequently provide both the link to these data sources as well as the author (or organisation) that was responsible for the construction thereof. From left to right in equation (3) (except for $\boldsymbol{z}_{ij,t}$):

- $X_{ij,t}$, representing trade flows in Euros from NUTS2 region i to NUTS2 region j at period t for $t \in \{t \in \mathbb{N} | 2000 \leq t \leq 2010\}$ (in nominal terms). These trade flows are constructed through the regionalisation of the WIOD supply and use tables of 2013 by a consorted effort from Thissen, Lankhuizen, Oort, Los and Diodato (2018). Internet link: https://data.overheid.nl/dataset/pbl-euregio-database-2000-2010

- $\delta_{ij,t}$, representing whether regions i and j belong to the same country at time t. This variable was generated from the $X_{ij,t}$ data. In order to allow for regional fixed effects, some countries that only had one NUTS2 region were merged in order to allow both regional and national border effects to be included. Slovenia and Malta (both had 1 NUTS2 region) were to that end merged with Italy; Cyprus was merged with Greece; Lithuania, Latvia and Estonia were merged into the Baltic states; and Romania and Bulgaria were also merged as one nation.

- $Euro_{ij,t}$, representing whether both region i and j have adopted the Euro at time t for $t \in \{t \in \mathbb{N} | 1995 \leq t \leq 2010\}$ as their official currency (*id est* banknotes and coins were introduced to the public). This data was retrieved from the website of the European Union and for the ones that adopted the Euro as 'book money' I used the ECB. Links: https://europa.eu/european-union/about-eu/countries_en#tab-0-0, https://www.ecb.europa.eu/ecb/history/emu/html/index.en.html

In addition to the aforementioned variables that constitute either the right hand side variable trade or the set of variables of interest $\boldsymbol{y}_{ij,t}$, I have also used a set of control variables $\boldsymbol{z}_{ij,t}$ as described in the methodology section and discussed at length in the data section. In a similar fashion to the aforementioned variables, I state the variable's full name and description in addition to its associated symbol in equation (3) and subsequently provide both the link to these data sources as well as the author (or organisation) that was responsible for the construction thereof:

- d_{ij}, representing the distance between trade flows in Euros from NUTS2 region i to NUTS2 region j (in kilometres). As mentioned in the data section and further elaborated in Appendix B on the construction of a NUTS2 distance matrix, I used data from Eurostat on GDP, employment and population figures for the weights

w_k and w_l and when necessary where linearly extrapolated as described in the Data section. Link: https://ec.europa.eu/eurostat/web/rural-development/data. In addition, I required data on road and airport distances (~GC distances) for all NUTS3 regions which was obtained from the TERCET database. For the road distances I used the 2016 flat files and for airport distances I used the 2013 flat files for both airport mappings onto NUTS3 and airports distances. TERCET data was sources were produced by Eurostat using GISCO data for the European Commission. Links: https://ec.europa.eu/eurostat/tercet/flatfiles.do.

- adj_{ij}, representing whether regions i and j share a common land border or connection such as a tunnel or a bridge. This data, like the data on distances between NUTS2 regions, did not yet exist to my knowledge and as such I constructed adjacency matrix between all NUTS2 regions by consulting NUTS2 maps which are readily available at the website of the European Commission. In addition I also used the documents provided on NUTS region changes to construct the crosswalks between PBL NUTS2, NUTS2 2013 and NUTS2 2016. Links: https://ec.europa.eu/eurostat/web/nuts/nuts-maps-.pdf- (NUTS2 maps), https://ec.europa.eu/eurostat/web/nuts/history (Changes in NUTS2)

- $Lang_{ij}$, representing whether regions i and j speak the same language. This data was constructed at the national level (no comprehensive overview by NUTS2 region was available to the best of my knowledge) using studies conducted by the Directorate-General for Translation in 2013 and TNS Opinion & Social in 2012. Internet Link:http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_386_en.pdf and https://publications.europa.eu/en/publication-detail/-/publication/1c672bb8-ffa8-11e5-b713-01aa75ed71a1/language-en/format-PDF/source-61885856

- $EU_{ij,t}$, representing whether both region i and j were regions under within the European Union at time t for $t \in \{t \in \mathbb{N} | 1995 \leq t \leq 2010\}$. Sources used to establish EU membership has been identical to those used for the variable $Euro_{ij,t}$. Link: https://europa.eu/european-union/about-eu/countries_en#tab-0-0

Appendix B: Distance Matrix Computation

Following Head and Mayer (2000; 2002), I construct average distance between NUTS2 regions i and j[36] from the weighted distances between all NUTS3 regions within both NUTS2 regions to obtain consistent intraregional, intranational and international distances. This implies more formally that for every NUTS3 region k within the exporting NUTS2 region i and NUTS3 region l within the importing NUTS2 region j, the distance between regions i and j is defined as:

$$d_{ij} = \sum_{k \in i} w_k \sum_{l \in j} w_l d_{kl} \quad \text{(B.1)}$$

Which is equivalent to first obtaining the weighted (by w_l) average distances from a NUTS3 region $k \in i$ to all NUTS3 regions $l \in j$, and subsequently averaging these average distances over all NUTS3 regions in the exporting region i to obtain the distance between the NUTS2 regions i and j. Head and Mayer (2000) define w_l as $w_l = GDP_l/GDP_j$ and $w_k = Emp_k/Emp_i$ (Emp represents employment) such that $\sum_{l \in j} w_l = 1$ and $\sum_{k \in i} w_k = 1$ [37]. Intuitively, this distance metric places more emphasis on the average distance from a NUTS3 region k to the NUTS3 region in j with the highest GDP as it is expected to be a larger consumer of the goods or services sold by region k. By weighing these average distances consecutively over employment for every region k, it intuitively also tries to capture the most likely origin NUTS3 region such that it emphasizes the distance between the NUTS3 region that most likely produces the most of these traded goods and services and the NUTS3 region k in j that is most likely to attract the largest share of these exports. This should yield results that are as close as possible to actual distance travelled by goods and services.

It is important to stress the fact that, as also emphasised by Head and Mayer (2000), it is in its essence a very data intensive process to compute these distances as data on both GDP and employment (preferably by sector) on the lower level of aggregation are needed. Head and Mayer (2002) hence imply using population weights ($w_l = POP_l/POP_j$ and $w_k = POP_k/POP_i$) to weigh the NUTS3 distances which are more easily obtainable even for small regions such as the NUTS3

[36] Note that this applies to all possible combinations of i and j, even if $i = j$ (i.e. intraregional distance). This ensures that the relative intraregional, intranational and international distances are by construction consistent which prevents obtaining biased (national and regional) border effect estimates owing to relative distance mismeasurement as documented in Head and Mayer (2000; 2002) and Havranek and Irsova (2017).

[37] Note that both GDP and Emp are both measured at the beginning of the period of analysis. In this study, these figures thus relate to the year 2000 (1st January). Population figures also correspond to the same period.

level, which deliver similar results. In addition, Head and Mayer (2000; 2002) resort to great circle distance between the NUTS3 regions as availability of longitudes and latitudes of these regions allow for relatively 'easy' computation of the distance between two regions. Braconier and Pisu (2013) improve upon this by also assessing the border effects robustness to using road distance as opposed to the great circle distance which *de facto* ignores geographical impediments to trade to a considerable degree[38]. They find that this would falsely increase average national border effects by approximately 17.6%[39], implying an important caution to the measure as used by Head and Mayer (2000; 2002).

This study draws upon these findings to construct a distance metric that aligns closely to the average distance metric designed by Head and Mayer (2000; 2002) whilst also incorporating the important critique to great circle distance by Braconier and Pisu (2013). To that end, I have constructed the distances by using *road* distances between all NUTS3 regions as provided by the TERCET database and weighted these distances with the asymmetric origin and destination weights as proposed in Head and Mayer (2000) (*id est* GDP and employment weighted) as well as the symmetric population weights as proposed in Head and Mayer (2002). As GDP and Emp were not always available on the NUTS3 level for the year 2000, I used a linear regional fixed effects regression with varying slope coefficients to linearly extrapolate these figures to 2000 if both these figures were available prior to 2009[40]. If GDP or employment was not available prior to 2009, I substituted these weights by the less intensive population weights, which was necessary for France, Poland and the Netherlands. As a robustness check, table 8-9 in Appendix E provides the estimated border effects for both symmetric and asymmetric weights in columns next to each other for direct comparison.

Furthermore, some concerns might however arise in response to the fact that trade between nations separated by sea might more heavily rely on shipping which would result in an overstated distance as the road distance would be relatively sizeable compared to the true distance travelled. In order to mitigate this effect, one would ideally use the distance from the NUTS3 region k to the nearest port and add this to the distance that is travelled across the sea to the nearest port to NUTS3 region l in addition to the distance from this nearest port to the NUTS3 region l.

[38] As a practical example, one could consider natural obstacles to trade in Europe such as the Pyrenees and the Alps as well as the Baltic (Sweden-Central European trade) which would considerably add to the distance travelled between two points on opposite sides of the mountain ranges

[39] This probably stems from the fact that mountain ranges and seas form natural barriers along which countries have historically organised. Hence, the additional distance incurred from these geographical impediments is falsely accredited to the national border.

[40]

Unfortunately, the TERCET database provides exclusively road distance data and the distances between airports together with the correspondence relationship between airports to the NUTS3 region where the airport has been located. Hence, as an imperfect but probably more appropriate substitute, I also compute a distance metric based on the minimalization of the road distance and road-airport-road distance. This metric is in nature more similar to great circle distance as the between airport distances are calculated using great circle distances. In the main body of the text, the latter distance metric has been used in assessing border effects as it increases comparability with other studies that rely on great circle distance (Cheptea, 2013; Mika, 2017) whilst limiting the bias that might originate from regions that might appear more distant on paper using road distances than these regions factually are. In addition, the border effects are strictly smaller when using exclusively road distances such that the estimates in the main body of the text can *de facto* be interpreted as the most conservative estimates[41].

Computational Details

More formally, this averaging over all regions $k \in i$ and $l \in j$ can also be written in matrix notation which has been used in the actual computation of the NUTS2 distance matrix (denoted by $D2$). Let every distinct NUTS3 region be given a unique number $x \in \{x \in \mathbb{N} \mid 1 \leq x \leq N\}$, where N denotes the total number of NUTS3 regions within the EU27, and let a and b define the row and column of any matrix or vector respectively. In addition, let: $D3_{ROAD}$ denote the distance matrix between all NUTS3 regions where $[D3]_{a,b}$ denotes the *road* distance from region $x = a$ to region $x = b$ (*id est* d_{ab}); $D3_{AIR}$ denote the distance matrix between all NUTS3 regions where $[D3]_{a,b}$ denotes the *road-air-road* distance from region $x = a$ to region $x = b$ (*id est* d_{ab}); every element in the $Nx1$ destination weight vector $\boldsymbol{w}_d$ be defined as $[\boldsymbol{w}_d]_{a,1} = GDP_a/GDP_j$ in the case of asymmetric weights and $[\boldsymbol{w}_d]_{a,1} = POP_a/POP_j$ for symmetric weights where j is the NUTS2 region to which the NUTS3 region with number $x = a$ corresponds; every element in the $Nx1$ origin weight vector $\boldsymbol{w}_o$ be defined as $[\boldsymbol{w}_o]_{a,1} = Emp_a/Emp_i$ in the case of asymmetric weights and $[\boldsymbol{w}_o]_{a,1} = POP_a/POP_i$ for symmetric weights where i is the NUTS2 region to which the NUTS3 region with number $x = a$ corresponds; $\mathbf{1}_{a\in i}$ and $\mathbf{1}_{a\in j}$ be the

[41] The results are already surprisingly low in comparison to other studies even when using a measure that effectively comes close to taking great circle distances. In order to not provide a 'misleading' comparison between my study's estimates and other recent studies within the academic literature, I have chosen to use the latter metric such that the discrepancy is most likely arising from the geospatial level at which the regions have been aggregated (*id est* regional level data versus national level data).

NxN indicator matrices with indicator functions on the diagonal with their respective subscript as the condition upon which the function takes the value of unity or zero. As such, one could rewrite equation B.1 (assuming the NUTS3 distance matrix used is $D3_{AIR}$) as:

$$d_{ij} = (\mathbf{1}_{a\in i}\boldsymbol{w}_o)^T D3_{AIR}\mathbf{1}_{a\in i}\boldsymbol{w}_d \qquad \text{(B.2)}$$

Note that B.2 can on its turn also be modified to yield the entire $D2$ matrix without computing d_{ij} piecewise. Let now W_o and W_d be the 252xN origin weight *matrix* with as rows $(\mathbf{1}_{a\in i}\boldsymbol{w}_o)^T$ and the Nx252 destination weight *matrix* with as columns $\mathbf{1}_{a\in i}\boldsymbol{w}_d$ respectively. Then $D2$ can easily be obtained by multiplying the distance matrix $D3$ from the left by the origin weight matrix W_o and from the right by the destination weight matrix W_d. Thus, $D2 = W_o D3_{AIR} W_d$.

Appendix C: Descriptive Statistics

Table 2 Descriptive Statistics by EU15 and EU12

	EU15							EU12						
		2000		2005		2010			2000		2005		2010	
	Observations	Mean	Median	Mean	Median	Mean	Median	Observations	Mean	Median	Mean	Median	Mean	Median
Time variant variables:														
Trade in goods	58176	86.483	7.18	95.807	9.46	102.606	9.19	19221	23.193	2.34	34.055	4	43.272	4.87
		(983.038)		(1034.564)		(1094.63)			(347.541)		(518.438)		(721.021)	
Trade in services	58176	170.648	1.44	213.103	2.18	234.906	2.04	19221	25.303	0.63	39.104	1.06	56.860	1.23
		(3234.786)		(3978.288)		(4488.773)			(566.961)		(902.84)		(1382.361)	
Fraction of Trade between EU members														
Fraction of Trade between EMU members														
Conditional averages and medians:														
Intranational trade in goods (δ=1)	4644	733.116	129.05	775.813	134.56	804.842	124.945	513	542.355	96.14	723.452	116.13	946.083	145.13
		(3399.985)		(3575.851)		(3782.971)			(2058.39)		(3089.851)		(4311.532)	
International trade in goods (δ=0)	53532	30.386	5.89	36.815	7.8	41.685	7.5	18708	8.957	2.21	15.151	3.81	18.516	4.615
		(90.183)		(102.61)		(120.088)			(23.230)		(38.170)		(48.829)	
Intranational trade in services (δ=1)	4644	2087.631	156.83	2594.76	202.57	2860.47	206.37	513	888.639	70.63	1371.838	87.89	2012.329	117.17
		(11274.3)		(13861.04)		(15650.93)			(3361.401)		(5363.686)		(8233.806)	
International trade in services (δ=0)	53532	4.346	1.22	6.49	1.86	7.134	1.72	18708	1.629	0.59	2.558	1.02	3.238	1.18
		(17.444)		(28.201)		(36.672)			(3.434)		(5.359)		(7.957)	
Time in-variant variables:														
Distance	60250	1356.748												
		(742.184)												
Adjacency	60250	0.017												
		(0.131)												
Common language	60250	0.541												
		(0.498)												

Notes: This table provides the descriptive statistics of both trade in goods and services (in millions of Euros) which are also separated by whether the trade flow is intra- or international. The descriptive statistics under EU15 (EU12) describe all trade flows in which an EU15 (EU12) country is either the exporter or importer. Standard deviation is provided below the mean in parentheses. Distances are measured in kilometres.

Table 3 Descriptive Statistics pooled across the EU27

		EU27					
		2000		2005		2010	
	Observations	Mean	Median	Mean	Median	Mean	Median
Time variant variables:							
Trade in goods	60025	88.726	7.36	99.836	9.84	108.681	9.58
		(987.211)		(1053.358)		(1151.6)	
Trade in services	60025	173.013	1.43	218.322	2.17	244.971	2.06
		(3200.457)		(3949.313)		(4487.18)	
Fraction of Trade between EU members	60025	0.680		0.984		1	
Fraction of Trade between EMU members	60025	0		0.400		0.437	
Conditional averages and medians:							
Intranational trade in goods (δ=1)	5047	727.742	127.44	784.957	135.31	833.56	128.99
		(3325.747)		(3567.035)		(3878.694)	
International trade in goods (δ=0)	54978	30.064	5.96	36.941	7.98	42.137	7.71
		(89.128)		(101.897)		(120.182)	
Intranational trade in services (δ=1)	5047	2011.115	151.49	2526.857	196.9	2836.423	205.35
		(10869.71)		(13405.4)		(15236.88)	
International trade in services (δ=0)	54978	4.275	1.19	6.397	1.84	7.075	1.72
		(17.224)		(27.846)		(36.227)	
Time in-variant variables:							
Distance	60250	1356.748					
		(742.184)					
Adjacency	60250	0.017					
		(0.131)					
Common language	60250	0.541					
		(0.498)					

Notes: This table provides the descriptive statistics of both trade in goods and services (in millions of Euros) which are also separated by whether the trade flow is intra- or international. The descriptive statistics under EU15 (EU12) describe all trade flows in which an EU15 (EU12) country is either the exporter or importer. Standard deviation is provided below the mean in parentheses. Distances have been measured in kilometres.

Appendix D: Tables Section IV

Table 3: Structural Gravity Estimates for Trade in Goods by EU15 and EU12

	EU15			EU12		
	(1)	(2)	(3)	(4)	(5)	(6)
National Border Effect						
Home National 2000	0.829***	0.852***		1.331***	1.358***	
	(0.236)	(0.242)		(0.221)	(0.227)	
Home National 2005	0.686**	0.706**	-0.110***	0.778***	0.807***	-0.421***
	(0.246)	(0.252)	(0.029)	(0.225)	(0.238)	(0.117)
Home National 2010	0.595*	0.611*	-0.205***	0.609*	0.717**	-0.479**
	(0.256)	(0.263)	(0.061)	(0.251)	(0.271)	(0.167)
Regional Border Effect						
Home Regional 2000	2.077***	2.044***		2.398***	2.386***	
	(0.395)	(0.398)		(0.150)	(0.154)	
Home Regional 2005	2.057***	2.024***	0.016	2.277***	2.265***	-0.053
	(0.398)	(0.401)	(0.019)	(0.195)	(0.200)	(0.052)
Home Regional 2010	2.117***	2.084***	0.056	2.286***	2.238***	-0.084
	(0.391)	(0.395)	(0.041)	(0.201)	(0.220)	(0.076)
The Euro's Effect						
Euro	0.300	0.345	-0.074	0.146	0.152	0.175
	(0.369)	(0.390)	(0.092)	(0.258)	(0.353)	(0.227)
Euro (t-5)	-0.0243	0.006	0.003			
	(0.049)	(0.115)	(0.121)			
Total Euro Effect			-0.071			0.175
(Significance)			(0.660)			(0.442)
Model Specifications						
Annual Data	Yes	No	No	Yes	No	No
Interval Data	No	Yes	Yes	No	Yes	Yes
Conventional Distances	Yes	Yes	Yes	Yes	Yes	Yes
Dyadic Fixed Effects	No	No	Yes	No	No	Yes

Notes: this table presents the border effect estimates (both national and regional) and the estimated Euro's effect on trade. Whilst no estimates of standard gravity variables such as distance and adjacency have been shown in this table, all of these variables take the expected sign (*id est* distance decreases trade as it increases and adjacency and common language both increase trade but are insignificant; see also table 6 for some of these coefficients). Standard errors, clustered by country-pair following Bergstrand et al. (2015), have been provided in parentheses beneath the coefficient estimates. Only the parentheses beneath the total Euro effect reflect p-values instead of standard errors. All specifications apply importer-time and exporter-time fixed effects as well as year fixed effects. in addition, all specifications above are estimated using PPML. Conventional distances refers to the usage of 'GC' distances as opposed to road distances. *p<0.05, **p<0.01, ***p<0.001

Table 4: Structural Gravity Estimates for Trade in Services by EU15 and EU12

	EU15			EU12		
	(1)	(2)	(3)	(4)	(5)	(6)
National Border Effect						
Home National 2000	3.073***	3.107***		0.923***	0.866***	
	(0.309)	(0.315)		(0.222)	(0.241)	
Home National 2005	3.042***	3.078***	-0.082	0.815***	0.756**	-0.196*
	(0.306)	(0.314)	(0.049)	(0.211)	(0.231)	(0.094)
Home National 2010	3.039***	3.069***	-0.093	0.884***	0.891***	-0.154
	(0.312)	(0.320)	(0.063)	(0.229)	(0.249)	(0.094)
Regional Border Effect						
Home Regional 2000	4.102***	4.102***		3.524***	3.507***	
	(0.521)	(0.523)		(0.140)	(0.132)	
Home Regional 2005	4.049***	4.048***	-0.023	3.454***	3.437***	0.014
	(0.517)	(0.519)	(0.019)	(0.161)	(0.151)	(0.011)
Home Regional 2010	4.025***	4.025***	-0.04	3.474***	3.456***	0.029
	(0.532)	(0.533)	(0.023)	(0.177)	(0.166)	(0.020)
The Euro's Effect						
Euro	-0.283	-0.553	-0.266*	-0.454*	-0.613*	-0.225
	(0.274)	(0.308)	(0.130)	(0.177)	(0.245)	(0.180)
Euro (t-5)	0.277*	0.248	0.214			
	(0.121)	(0.172)	(0.170)			
Total Euro Effect			-0.052			-0.225
(Significance)			(0.805)			(0.212)
Model Specifications						
Annual Data	Yes	No	No	Yes	No	No
Interval Data	No	Yes	Yes	No	Yes	Yes
Conventional Distances	Yes	Yes	Yes	Yes	Yes	Yes
Dyadic Fixed Effects	No	No	Yes	No	No	Yes

Notes: this table presents the border effect estimates (both national and regional) and the estimated Euro's effect on trade. Whilst no estimates of standard gravity variables such as distance and adjacency have been shown in this table, all of these variables take the expected sign (*id est* distance decreases trade as it increases and adjacency and common language both increase trade; see also table 7 for some of these coefficients). Standard errors, clustered by country-pair following Bergstrand et al. (2015), have been provided in parentheses beneath the coefficient estimates. Only the parentheses beneath the total Euro effect reflect p-values instead of standard errors. All specifications apply importer-time and exporter-time fixed effects as well as year fixed effects. in addition, all specifications above are estimated using PPML. Conventional distances refers to the usage of 'GC' distances as opposed to road distances. *p<0.05, **p<0.01, ***p<0.001

Table 5: Structural Gravity Estimates for Trade in Goods and Services for the EU27 (pooled)

	Goods Trade			Service Trade		
	(1)	(2)	(3)	(4)	(5)	(6)
National Border Effect						
Home National 2000	0.789**	0.802**		3.122***	3.157***	
	(0.247)	(0.252)		(0.315)	(0.321)	
Home National 2005	0.642*	0.668*	-0.112***	3.088***	3.126***	-0.086
	(0.257)	(0.263)	(0.029)	(0.313)	(0.321)	(0.048)
Home National 2010	0.543*	0.551*	-0.212***	3.094***	3.127***	-0.093
	(0.268)	(0.274)	(0.062)	(0.319)	(0.327)	(0.063)
National Border Effect x 1{EU12}						
Home National 2000 x 1{EU12}	0.805*	0.702		-2.476***	-2.479***	
	(0.349)	(0.367)		(0.429)	(0.450)	
Home National 2005 x 1{EU12}	0.516	0.461	-0.300**	-2.365***	-2.445***	0.017
	(0.373)	(0.388)	(0.116)	(0.407)	(0.423)	(0.098)
Home National 2010 x 1{EU12}	0.654	0.652	-0.173	-2.617***	-2.598***	-0.123
	(0.384)	(0.402)	(0.181)	(0.390)	(0.415)	(0.111)
Regional Border Effect						
Home Regional 2000	2.176***	2.137***		4.106***	4.104***	
	(0.390)	(0.393)		(0.519)	(0.520)	
Home Regional 2005	2.157***	2.118***	0.016	4.052***	4.050***	-0.023
	(0.393)	(0.395)	(0.019)	(0.515)	(0.516)	(0.019)
Home Regional 2010	2.221***	2.183***	0.059	4.029***	4.026***	-0.04
	(0.386)	(0.389)	(0.042)	(0.530)	(0.531)	(0.023)
Regional Border Effect x 1{EU12}						
Home Regional 2000 x 1{EU12}	-0.156	-0.163		-0.555	-0.528	
	(0.355)	(0.356)		(0.522)	(0.523)	
Home Regional 2005 x 1{EU12}	-0.218	-0.209	-0.072	-0.563	-0.540	0.041
	(0.371)	(0.373)	(0.058)	(0.533)	(0.534)	(0.022)
Home Regional 2010 x 1{EU12}	-0.272	-0.263	-0.147	-0.530	-0.505	0.069*
	(0.370)	(0.370)	(0.090)	(0.554)	(0.555)	(0.031)
The Euro's Effect						
Euro	0.204	0.274	-0.067	-0.244	-0.520	-0.226
	(0.320)	(0.351)	(0.084)	(0.243)	(0.291)	(0.122)
Euro (t-5)	0.0569	0.169	0.015	0.237*	0.147	0.180
	(0.063)	(0.139)	(0.119)	(0.118)	(0.173)	(0.165)
Total Euro Effect			-0.052			-0.046
(Significance)			(0.741)			(0.826)
Model Specifications						
Annual Data	Yes	No	No	Yes	No	No
Interval Data	No	Yes	Yes	No	Yes	Yes
Conventional Distances	Yes	Yes	Yes	Yes	Yes	Yes
Dyadic Fixed Effects	No	No	Yes	No	No	Yes

Notes: this table presents the border effect estimates (both national and regional) and the estimated Euro's effect on trade. Whilst no estimates of standard gravity variables such as distance and adjacency have been shown in this table, all of these variables take the expected sign. Complete heterogeneity between EU12 and EU15 members has been allowed for in $\boldsymbol{z}_{ij,t}$. Standard errors, clustered by country-pair following Bergstrand et al. (2015), have been provided in parentheses beneath the coefficient estimates. Only the parentheses beneath the total Euro effect reflect p-values instead of standard errors. All specifications apply importer-time and exporter-time fixed effects as well as year fixed effects. in addition, all specifications above are estimated using PPML. Conventional distances refers to the usage of 'GC' distances as opposed to road distances. *p<0.05, **p<0.01, ***p<0.001

Table 6: Robustness Checks for Trade in Goods for the EU15 and EU12

	EU15				EU12			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
National Border Effect								
Home National 2000	0.214	0.852***	0.846***	1.032***	1.031**	1.358***	1.283***	1.196***
	(0.340)	(0.242)	(0.240)	(0.267)	(0.328)	(0.227)	(0.219)	(0.196)
Home National 2005	0.147	0.706**	0.706**	0.827**	0.481	0.807***	0.742**	0.790***
	(0.364)	(0.252)	(0.251)	(0.282)	(0.338)	(0.238)	(0.228)	(0.204)
Home National 2010	0.161	0.611*	0.613*	0.737*	0.637	0.717**	0.654*	0.734**
	(0.397)	(0.263)	(0.262)	(0.292)	(0.382)	(0.271)	(0.261)	(0.240)
Regional Border Effect								
Home Regional 2000	1.160***	2.044***	2.074***	3.483***	0.368	2.386***	2.348***	3.437***
	(0.249)	(0.398)	(0.396)	(0.349)	(0.342)	(0.154)	(0.154)	(0.184)
Home Regional 2005	1.106***	2.024***	2.053***	3.468***	0.298	2.265***	2.228***	3.338***
	(0.254)	(0.401)	(0.398)	(0.353)	(0.387)	(0.200)	(0.200)	(0.224)
Home Regional 2010	1.244***	2.084***	2.113***	3.518***	0.232	2.238***	2.200***	3.310***
	(0.251)	(0.395)	(0.393)	(0.349)	(0.434)	(0.220)	(0.220)	(0.241)
The Euro's Effect								
Euro	0.038	0.345	0.311	0.599	0.073	0.152	0.154	0.083
	(0.167)	(0.390)	(0.390)	(0.323)	(0.211)	(0.353)	(0.350)	(0.326)
Euro (t-5)	0.198	0.006	0.008	-0.007				
	(0.120)	(0.115)	(0.115)	(0.112)				
Standard Gravity Variables								
Adjacency	-0.605***	0.151	0.157	0.757***	-1.065***	-0.185	-0.202	0.211***
	(0.160)	(0.213)	(0.212)	(0.196)	(0.130)	(0.104)	(0.104)	(0.057)
Distance	-1.668***	-0.836***	-0.803***		-1.854***	-0.738***	-0.754***	
	(0.112)	(0.096)	(0.092)		(0.132)	(0.085)	(0.084)	
Model Specifications								
Interval Data	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Conventional Distances	Yes	Yes	No	No	Yes	Yes	No	No
Road Distances	No	No	Yes	No	No	No	Yes	No
Interval Distances	No	No	No	Yes	No	No	No	Yes
Estimation Method	OLS	PPML	PPML	PPML	OLS	PPML	PPML	PPML

Notes: this table presents the border effect estimates (both national and regional) and the estimated Euro's effect on trade. Standard errors, clustered by country-pair following Bergstrand et al. (2015), have been provided in parentheses beneath the coefficient estimates. Only the parentheses beneath the total Euro effect reflect p-values instead of standard errors. All specifications apply importer-time and exporter-time fixed effects as well as year fixed effects. Conventional distances refers to the usage of 'GC' distances as opposed to road distances. *p<0.05, **p<0.01, ***p<0.001

Table 7: Robustness Checks for Trade in Services for the EU15 and EU12

	EU15				EU12			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
National Border Effect								
Home National 2000	2.798***	3.107***	3.104***	3.165***	0.625*	0.866***	0.841***	0.775***
	(0.213)	(0.315)	(0.315)	(0.341)	(0.284)	(0.241)	(0.240)	(0.213)
Home National 2005	2.647***	3.078***	3.076***	3.123***	0.49	0.756**	0.732**	0.723***
	(0.243)	(0.314)	(0.314)	(0.340)	(0.295)	(0.231)	(0.229)	(0.198)
Home National 2010	2.895***	3.069***	3.068***	3.114***	0.613*	0.891***	0.858***	0.868***
	(0.244)	(0.320)	(0.321)	(0.347)	(0.275)	(0.249)	(0.246)	(0.212)
Regional Border Effect								
Home Regional 2000	3.901***	4.102***	4.090***	4.425***	3.043***	3.507***	3.494***	4.107***
	(0.280)	(0.523)	(0.519)	(0.405)	(0.319)	(0.132)	(0.145)	(0.302)
Home Regional 2005	3.885***	4.048***	4.036***	4.371***	3.060***	3.437***	3.425***	4.040***
	(0.301)	(0.519)	(0.515)	(0.398)	(0.338)	(0.151)	(0.166)	(0.327)
Home Regional 2010	3.867***	4.025***	4.013***	4.347***	3.047***	3.456***	3.444***	4.060***
	(0.325)	(0.533)	(0.530)	(0.413)	(0.372)	(0.166)	(0.181)	(0.339)
The Euro's Effect								
Euro	-0.212	-0.553	-0.564	-0.509	-0.518**	-0.613*	-0.608*	-0.582**
	(0.148)	(0.308)	(0.308)	(0.305)	(0.180)	(0.245)	(0.245)	(0.224)
Euro (t-5)	0.399*	0.248	0.248	0.251				
	(0.158)	(0.172)	(0.172)	(0.172)				
Standard Gravity Variables								
Adjacency	0.909***	1.154***	1.145***	1.294***	0.129	0.503***	0.494***	0.655***
	(0.228)	(0.217)	(0.217)	(0.233)	(0.149)	(0.133)	(0.130)	(0.102)
Distance	-0.762***	-0.186*	-0.188*		-1.014***	-0.461**	-0.462***	
	(0.081)	(0.086)	(0.084)		(0.100)	(0.154)	(0.138)	
Model Specifications								
Interval Data	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Conventional Distances	Yes	Yes	No	No	Yes	Yes	No	No
Road Distances	No	No	Yes	No	No	No	Yes	No
Interval Distances	No	No	No	Yes	No	No	No	Yes
Estimation Method	OLS	PPML	PPML	PPML	OLS	PPML	PPML	PPML

Notes: this table presents the border effect estimates (both national and regional) and the estimated Euro's effect on trade. Standard errors, clustered by country-pair following Bergstrand et al. (2015), have been provided in parentheses beneath the coefficient estimates. Only the parentheses beneath the total Euro effect reflect p-values instead of standard errors. All specifications apply importer-time and exporter-time fixed effects as well as year fixed effects. Conventional distances refers to the usage of 'GC' distances as opposed to road distances. *p<0.05, **p<0.01, ***p<0.001