The Gains from Economic Integration *

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August 17, 2018

Abstract

This paper measures the effect of political integration, such as sharing a national state or economic union, on the degree of trade integration. Consistently with previous work, we find large border effects. However, such estimates may be biased and overestimate the effects of borders because of endogeneity: selection into sharing a political space is correlated with affinities for trade. We propose a method to address this and we produce estimates which are closer to the causal effect. We then conduct speculative exercises showing the costs and benefits of the changing levels of integration associated with: the independence of Scotland, Catalonia and the Basque Country from the UK and Spain (but remaining within the European Union); the UK's exit from the EU; the break-up of the EU itself; and closer integration within the EU so that its internal borders appear similar to the internal borders of individual countries (as opposed to its current state of being simply a closely integrated group of countries). We find that the border effect between countries is an order of magnitude larger than the border effect associated with the European Union.

Key words: Border effect, trade, independence. **JEL Classification:** F15, R13

*We thank Doireann Fitzgerald, Beata S. Javorcik, Tim Kehoe, Nick Meyers, Josep Pijoan, Pau Pujolas, Robert Zymeck and seminar participants at Edinburgh, the Minneapolis Fed, McMaster, SED and RES for very useful comments and advice.

1 Introduction

The aim of this paper is to measure the effect of political integration, such as sharing a national state or economic union, on the degree of trade integration, and to quantify its welfare implications. We define *the economic integration* as the causal effect of sharing political space upon welfare - this is the additional welfare gained by entities which come together to form a country or an economic union, due to increased trade.

We calibrate a structural trade model to interregional and international trade data, and obtain the implicit trade frictions that would explain the observed data, something often referred to as the Head Ries Index (HRI)[1]. We do this while treating countries and sub-national units for which we have data, as entities with the same status within a common framework. We define *the average border effect* as the average difference between the interregional and the international frictions, controlling for physical distance, common language, and size. Likewise the average effect of the European Union is the average difference between frictions within and across the EU boundary, controlling for those same characteristics. The existence of very large border effects, even within the European Union, is well known[2] and in this paper we also find large average border effects.

Our main point though is that these average border effects are bound to overestimate the gains from sharing a state. This is because places which share larger affinities are more likely to both trade with each other and to select into sharing a political space (a country, or EU membership). Due to this endogeneity the average effect likely overstates the reductions in trade frictions achieved by sharing a political space.

For instance, the fact that Scotland and England share a country is related to the fact that they trade a lot - but we cannot claim that the high volume of trade is all caused by the fact of

[1]According to Head and Mayer (2014), Eaton, Kortum, Neiman, and Romalis (2016) coin the label "Head-Ries Index" since this "indicator first appears in Head and Ries (2001)".

[2]Many papers in the economics of international trade literature have looked at the border effect, starting with the seminal contribution of McCallum (1995). This empirical work was embedded into the modern trade theory literature by Anderson and van Wincoop (2003) who found a substantial border effect that differentiated trade between U.S. states and Canadian provinces. The theory consistent econometric estimation approach of Anderson and van Wincoop (2003) is what is typically used in this literature, for example Coughlin and Novy (2013) compare the magnitude on the coefficients of U.S. state-international borders and state-state borders and conclude that the incremental friction increase is greater when comparing state-state trade to intra-state trade, than it is for state-international trade to state-state trade. Our results for the average differences between interregional and international borders are consistent with the estimates from Anderson and van Wincoop (2003).

state sharing. Scotland and England would trade at a relatively high rate even if they did not share a country. The affinities that lead to trade between the two also increase the likelihood of nation state sharing. The causal effect of nation state sharing can be quantified by only changing the status of state sharing or not - not by also changing these affinities. Looking at the average difference in trade within and across national borders, even when controlling for physical distance and common language, does not compare like with like in terms of these affinities. The average friction between the UK with the rest of the countries of the world, after controlling for physical distance, size and language, is much larger than the frictions that plausibly would exist between Scotland and England in the case of independence, even if in that case the frictions were larger than the ones that we observe today. We would overstate the costs of political separation if we were to augment the current Scotland-England frictions with the average border effect.

Our approach to deal with this endogeneity problem has a certain resemblance (at least in spirit) to regression discontinuity analysis (see Imbens and Lemieux (2008)) or synthetic control methods (see Abadie, Diamond, and Hainmueller (2010))[3]. We identify *"marginal regions"*, defined as regions or countries whose leadership seeks to exit the political space under consideration (e.g. Scotland seeking independence from the UK). We also identify *"marginal countries"*, based on the countries with the smallest frictions with the country to which the *"marginal region"* currently belongs (e.g. Ireland is the natural counterfactual to Scotland with respect to the UK). Essentially *"marginal regions"* are regions of a larger country that could conceivably be independent, and *"marginal countries"* are independent countries that could easily be regions of the larger country. This comparison should be clean of the endogeneity problem insofar as the ex-ante probabilities for the "marginal country" and the "marginal region" to form a political union to the country to which the "marginal region" belongs, are similar. And insofar as this comparison is clean of the endogeneity problem, it should give us estimates which are closer to the causal impact of sharing political space. Conducting counterfactual exercises based on the difference in frictions between

[3]Regression discontinuity and synthetic control methods exploit the existence of pre and post treatment periods in the data, with a control that matches the treated population in the pre-treatment period. The observed difference between treated and untreated control in the post-treatment period can then be interpreted as the causal impact of the treatment. In our case, the treatment is political integration, and seek to identify "treated" and "untreated" entities which are as close to being marginal cases as possible. Our methods for doing this are necessarily somewhat arbitrary, but are nevertheless interesting, produce results which confirm the intuition of an issue with endogeneity, and may yield some general insights.

"marginal region" and *"marginal country"* allows us to quantify welfare implications.

For example we estimate the value of Scotland's economic integration within the UK by comparing welfare values calculated using the measured Scotland-rest of the UK friction, and the measured Ireland-UK friction (because Ireland is observed to have the lowest measured frictions with the UK). In addition to having the lowest measured friction with the UK, Ireland is similar in size to Scotland, shares a common language with Scotland and the rest of the UK, is contiguous with the UK (via Northern Ireland), and shares much common history (including formerly being part of the UK) - and so we observe that our methodology produces appropriate and interesting counterfactuals.

An issue that could be potentially damaging for our approach to measuring the welfare change induced by political integration, is the possibility that the degree of political integration between two entities A and B may affect the economic frictions between each of them and a third party C. For instance, we will argue that loosening political integration between two entities (for instance, Scotland becoming independent from the UK) will increase the frictions between Scotland and the rest of the UK, but it is in principle possible that independence could also change the frictions between Scotland and the rest of the world (presumably decreasing them). If that were the case, our approach would overstate the welfare gains of political integration. We show though, that this does not seem to be the case. Marginal regions in our analysis have frictions with the rest of the world are in line with those of similarly sized independent countries. In this sense, economic integration is a gain: it does not appear to be achieved at the expense of higher frictions with the rest of the world.

We conduct speculative exercises to illustrate the quantitative importance of economic integration. We consider the independence scenarios for Scotland, Catalonia, and the Basque Country, as well as looking at "Brexit": the exit of the UK from the European Union. Furthermore we look at combinations of these such as Scotland staying in the EU by becoming independent as the rest of the UK undergoes Brexit. Finally, we consider scenarios which look at the disintegration of the EU, as well as the possibility that the EU furthers its degree of economic integration across countries to the same level that there is within its member states.

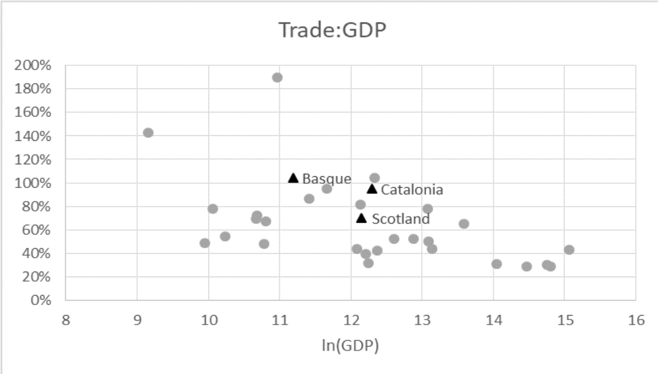
Welfare impacts can easily be quantified following the contribution of Arkolakis, Costinot, and Rodríguez-Clare (2012) who show that the welfare impact of a given change in trade flows, subject to parameters, are the same in all trade models within the class of 'gravity models', and given by a simple formula[4]. The productivity or welfare implications of changes in trade frictions can be examined using policy experiments, and this has been done in many papers in the literature[5]. In this paper we evaluate the welfare impacts of changing frictions by the magnitude measured between our marginal regions and marginal countries as an estimate towards what may be the causal impact of state-sharing. Although we have only a few cases to consider in our data, and the welfare impacts are different in each case, we do observe a pattern that suggests we may be able to make a general claim. In all the examples that we look at, and independently of parameters, the welfare cost of losing the economic integration a region has with the rest of its country, relative to the welfare cost of autarky, is between one third and one half, i.e. economic integration within a larger country seems to account for between one third and one half of the total gains from trade relative to autarky for regions of the size of Scotland, Catalonia and the Basque Country.

We show that the average econometric estimation exercise (not taking into account the endogeneity) over-estimates the causal effect of sharing a country upon economic integration. Nevertheless, the value of such economic integration once controlling for this endogeneity is still substantial. Belonging or not to the EU also has quantitatively significant welfare effects, but these are observed to be almost an order of magnitude less significant than the impact of sharing a country.

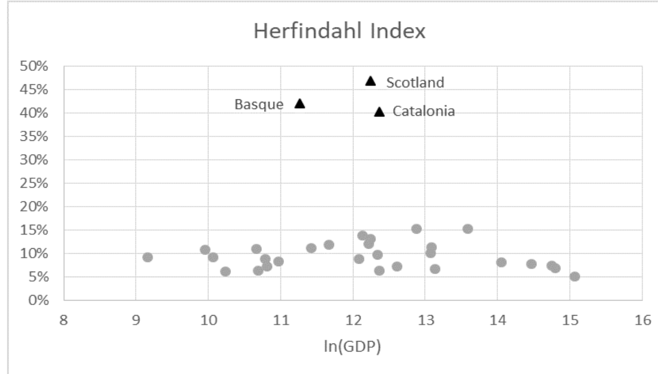
We do not explain the institutional arrangements or mechanisms that lead to economic integration within countries, we simply identify the size of this integration, and quantify its importance

[4] Though particular microfoundations are suggestive of particular values for the parameters and so do matter, a point made by Melitz and Redding (2015). The microfoundations can be very different, e.g.: a love of variety means that the available product range expands with the size of the market and leads to aggregate increasing returns to scale, as in Krugman (1980); a larger market can lead to better firm selection as efficient firms expand to serve this larger market, putting upward pressure on wages, and lowering profitability of low productivity firms who exit, as in Melitz (2003); and traditional Ricardian trade explanations as in Eaton and Kortum (2002). All imply different structural interpretations, and hence different parameter values. Further, the simple formula is different for different sub-classes of gravity models: in this paper we use a gravity model with tradable intermediate goods as discussed in Section IV of Arkolakis, Costinot, and Rodríguez-Clare (2012).

[5] Costinot and Rodríguez-Clare (2014) is a review of this literature. Examples of papers within this literature are Bernard, Eaton, Jensen, and Kortum (2003) (examines the impact of a drop in all frictions of 5% in a calibrated model); and Corcos, Gatto, Mion, and Ottaviano (2012) (examines a number of policy experiments including undoing non-tariff barrier liberalisations associated with EU membership, implementing 5% tariff barriers on trade with the world outside EU, and implementing 5% tariffs on all international trade). Head and Mayer (2014) provide a toolkit for implementing such policy experiments in general equilibrium.



(a) Trade:GDP ratio of EU countries, plus Scotland, Catalonia & Basque Country



(b) Herfindahl Index of Trade Concentration of EU countries, plus Scotland, Catalonia & Basque Country

Figure 1: Trade and trade concentration in regions and countries

within a modern general equilibrium model of trade. The differences in the degree of economic integration may be due to many reasons: biases in government procurement[6], home bias in preferences, regulation favouring local firms, political economy biases, migratory patterns, network formation, etc. In this paper we simply point to the facts and leave the investigation of potential causes to further research[7].

* * * * *

We begin our analysis with an illustration showing that something happens within countries that is different from what happens across countries: the patterns of trade for regions that very plausibly could be independent countries are very different from those of independent countries. These regions exhibit a very high degree of trade concentration that marks them out as very different from otherwise similar countries within the EU. If we treat Scotland, Catalonia, and the Basque Country as if they were independent countries and compare their trade patterns with those of the other EU members, we see immediately that the most remarkable difference between these regions and the other countries is not how much they trade, but rather how much they

[6]In a recent paper, Herz and Varela-Irimia (2016) using the universe of public procurement contracts within the EU show that the nationality of the winner of the contract (the supplier) is its most salient characteristic. The border effect in public procurement *within the EU* is enormous, in spite of being explicitly prohibited by the Union treaties to discriminate in favor of domestic suppliers.

[7]A recent literature on internal frictions is also helpful in moving forward this research agenda, for example Atkin and Donaldson (2015), Cosar, Grieco, and Tintelnot (2015), and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016).

concentrate their trade with a single partner: the rest of the country to which they belong. Figure 1a[8] shows that the trade share of these regions is typical in a European context, but Figure 1b highlights how anomalous these regions' trade concentrations are compared with EU countries. It shows the Herfindahl index of trade concentration[9], and it shows the regional Herfindahl Indices as much higher than that of even the most trade concentrated independent EU members[10]: it's almost an order of magnitude type comparison. Our exercise will consist of building reasonable counterfactuals for these regions where they appear as normal countries.

The paper is structured as follows. In Section 2 we develop the Head Ries Index framework for measuring trade frictions, present our cross country and region comparison results (including some interesting results on the differences in the degree of home bias between trade in goods and trade in services), and show the (unsurprising) result that a large border effect exists. Section 3 develops our argument on the endogenous selection of economies into regions and countries - the average border effect is an upwardly biased estimate of the causal effect of the impact of political integration upon trade frictions. In this section we also describe our method of dealing with this selection bias. In Section 4 we conduct counterfactual experiments on regional borders in which we show that, even after allowing for this selection bias, a substantial impact remains. The value of integration across the European Union is considered in Section 5, in which we provide some quantification for the costs of Brexit. Section 6 concludes.

2 Measuring Trade Frictions

In this section we show that the border effect, understood as the average difference in bilateral frictions between interregional and international pairs within the EU, is very large. Furthermore, the EU border effect, understood as the average difference in bilateral frictions between EU pairs

[8]The data used in for these graphs, and throughout the paper, is described in Appendix A

[9]If there are N countries, with the exports from country h to country j denoted X_j^h ($X_h^h \equiv 0$), then the Herfindahl Index for country h, $H_h = \sum_{j=1}^{N}[(X_j^h/\sum_{k=1}^{N}[X_k^h])^2]$. $H_h = 1$ indicates complete concentration of trade with a single trading partner. $H_h \to 0$ indicates diversification of trade across all partners.

[10]The most trade concentrated independent EU member is Austria, a relatively small country which concentrates its trade with the EU's largest economy, Germany.

and other country pairs, is smaller but still significant. Differences of the magnitudes that we obtain have quantitatively significant welfare implications if they were to be interpreted as the causal effect of borders.

Gravity models of trade are of the form:

$$\ln X_{hj} = \gamma_0 + \ln Y_h + \ln Y_j - \gamma_h d_h - \gamma_j d_j + \epsilon \ln \delta_{hj} \tag{1}$$

Many structural trade models produce such a gravity equation, in which the log of trade is directly proportional to the log of the GDPs of the countries involved, and inversely proportional to country fixed effects which represent the total demand from across the world for the output from which this trade flow is drawn (often referred to as "multilateral resistance"). The residual after allowing for GDP and multilateral resistance is the trade friction. δ_{hj} is the variable trade costs and so $\epsilon < 0$ is the "trade elasticity", i.e. the elasticity of trade volumes to variable trade costs.

In many trade structural models, including the model that we will develop in section 4, the trade frictions can be calibrated from the trade flow data as the "Head Ries Index" (HRI), given by the following expression:

$$\delta_{hj} = \left(\frac{X_{hj}^2}{X_{hh} X_{jj}} \right)^{\frac{1}{2\epsilon}} \tag{2}$$

A larger Head Ries Index indicates larger trade frictions and (ceterus paribus) lower trade volumes. The HRI is the trade friction that would produce the observed bilateral trade within a gravity model (conditional on a given value for the trade elasticity). It is a very natural and theory compatible measure of trade frictions, and has been used many times in the literature[11].

There are two considerations about the HRI that are important to remark on.

(1) Its measured value does, of course, depend on the value of the trade elasticity used. In most of our specifications we will use the values of ϵ that are commonly accepted in the literature

[11] Chen and Novy (2012) label this approach to trade friction measurement as the "Indirect Approach". Other papers which have used this approach include Head and Ries (2001), Eaton, Kortum, Neiman, and Romalis (2016), Novy (2013), Chen and Novy (2011), Head and Mayer (2004), and Jacks, Meissne, and Novy (2011). The HRI between entities i and j is monotonically related to the iceberg cost that appears in many trade models and so is a measure of the total trade frictions between i and j. The version of the HRI used here is that implied by models which produce bilaterally balanced trade.

(more on this below). Nevertheless, we will present a result that suggests that we can make a more general claim that is not sensitive to the specific value for ϵ that is used.

(2) It measures the frictions of trading outside your entity *relative* to the frictions of trading internally within your own entity, as it is assumed that $\delta_{hh} \equiv 1$. Therefore, we must control for country size, as otherwise we would be biasing welfare considerations in favor of large countries, as they "enjoy" a larger market with zero frictions by assumption. When we do comparisons we either do it between entities of approximately the same size, or we control for the econometrically estimated effect of size.

We perform a simple econometric exercise, regressing for all pairs of countries and regions, the Head Ries Index measured for each bilateral pair, against the incomes of each party, the physical distance between them (and this distance squared), a common language dummy, regional border dummies, and a non-EU border dummy[12].

First we outline the data, and then we describe the results of our exercise.

2.1 Data & Methodology

The data used in this paper is fully described in Appendix A. But briefly it is: international data from the WIOD database covering both goods and services; regional data for the USA, Canada, Spain, and Scotland, is taken from local statistical agencies; international, Scottish, and US data is from 2014; Canadian data is from 2013; Basque Country (goods and services) data is from 2006; and Catalan (goods and services) data is from 2005; for the rest of Spanish Autonomous Communities we have goods only data from 2006. The following procedure is followed to construct an internally consistent dataset:

- From the international data we have: X_j^h, the trade flow from h to j; the Gross Output, X_h, and the GDP_h, for all countries $h \in \{1, ..., N\}$.

[12]This is very similar to running a standard gravity regression of bilateral trade upon GDPs and upon dummies for i and j, with explanatory terms for trade frictions: $\ln X_{hj} - \ln Y_h - \ln Y_j = \gamma_0 + \gamma_h d_h + \gamma_j d_j + \epsilon\left(\alpha_1 E_1 + ... + \alpha_m E_m\right)$ where d_k is a dummy variable for k (so γ_k gives its multilateral resistance), where ϵ is the trade elasticity, and where $E_1, ..., E_m$ are m factors with which we try to explain trade frictions. Imposing theory consistent restrictions upon the multilateral resistance terms, and moving terms to the left hand side, the estimation equation reduces to $\frac{1}{\epsilon}\left(\ln X_{hj} - \frac{1}{2}\ln X_{hh} - \frac{1}{2}\ln X_{jj}\right) \equiv \ln \delta_{hj} = \alpha_1 E_1 + ... + \alpha_m E_m$, which is what we do.

- Then define:

$$X_{hj} = \frac{1}{2}\left(X_h^j + X_j^h\right) \quad (3)$$

$$X_{hh} = X_h - \sum_{j \neq h} X_{hj} \quad (4)$$

where (3) determines the bilateral trade interaction as the average of imports and exports[13], and (4) defines the amount of internal trade as the difference between gross output and external trade.

- For each region in our data, we construct a data pair comprising of the region and a virtual "rest of the country", by applying the share of income, the share of external trade, and the ratio of internal trade to external trade, implied by the regional dataset, to the output and international trade from the country dataset[14].

Note that when we try to measure trade frictions consistently across countries and regions and to conduct some basic statistical analysis on these measures, the US states supply the bulk of our regional data points. The US and Spanish regional trade datasets are for goods trade only. We therefore use goods only data for Canada despite goods and services data being available, and we exclude Scotland from the database at this stage. We use the ratio of, say, Texas goods trade with the rest of the USA to its goods trade with the rest of the world, combined with the Texan share of US goods trade with the rest of the world, to generate a consistent measure of Texas's internal trade, from the USA's external combined goods and services trade. Given data limitations, this is a reasonable procedure. But we can infer in which direction it biases our results from the Canadian, Basque, and Catalan data, and it seems to matter quantitatively - we will come back to this. In Section 4 we use goods and services data for Scotland, Catalonia, and the Basque Country[15].

[13]Note that instead of defining our measure of the trade interaction between the entities as the arithmetic average of imports and exports, we could use the geometric average: $X_{hj} = (X_h^j X_j^h)^{\frac{1}{2}}$. We also tried this and it made very little difference to the estimates shown in Table 1.

[14]For example, Catalan output is given by Spanish output from the cross-country dataset multiplied by the ratio of Catalan GDP to Spanish GDP from the regional dataset. Catalan trade with the rest of the world is given by this Catalan output multiplied by the Catalan external trade to output ratio. Catalan trade with the rest of Spain is given by this Catalan external trade multipled by the internal to external trade ratio. Finally, the figures for the rest of Spain are given by the Spanish figures less the Catalan ones.

[15]It is in itself interesting that out of all the autonomous communities of Spain, the regions with substantial

To calculate the HRI for the countries and regions in our dataset, we must choose a trade elasticity, ϵ. There is much discussion in the literature (see e.g. Simonovska and Waugh (2014) and Melitz and Redding (2015)) about the appropriate value for the trade elasticity, but based loosely on Simonovska and Waugh (2014), for this exercise we choose $\epsilon = -3.5$[16]. In Section 4 we will reach a conclusion that is extremely insensitive to this choice.

2.2 Average Border Effect Results

We take logs of the set of calculated HRIs and regress against log of gross output, distance, distance squared, common language and border dummies.[17]

We have three different types of border dummies. The regional border dummy takes value 1 only if it is a border between regions of the same country. The non EU border dummy takes value 1 only if it is a border between a non EU country and another country (EU or not). Finally, we include separate dummies for Canadian and Spanish region to region borders to account for country fixed effects representing differential levels of internal integration between the US, Canada, and Spain (to avoid collinearity, there is no US specific border dummy, so the coefficient on the overall regional dummy measures the US border, whilst the coefficients on the regional dummy plus the Canadian or Spanish dummies measures the borders for Canada or Spain respectively).

These results are shown in Table 1. The dummy variable specification chosen means that everything is measured relative to the cross country borders between EU member states. The positive sign on the non-EU border coefficient means that cross country borders that are not internal to the EU are significantly more frictional than internal EU borders. The negative sign on the regional border coefficient suggests that US internal borders are substantially less frictional than country to country borders within the EU. The negative sign on the Canada coefficient

independence movements, Catalonia and the Basque Country, are the only two with their own local statistical agencies that produce goods and services data.

[16] Simonovska and Waugh (2014) who report a range of figures for the trade elasticity based on different trade models. Their range is from −2.8 given the model from Bernard, Eaton, Jensen, and Kortum (2003), to −5.2 given the Armington model (Anderson and van Wincoop (2003)) or Krugman (1980) model. Our chosen parameter value is somewhere in the middle of this range and close to the figure of −3.41 which Simonovska and Waugh (2014) estimate for the Melitz (2003) model.

[17] We also tried adding a common currency dummy, but the estimated coefficient on this variable was insignificant, and its inclusion did not change the coefficients on anything else by very much at all. Therefore, we report the results only from the specification omitting this variable.

	Coef.
Constant	4.376***
	(0.102)
distance in km	0.0001381***
	(0.0000069)
distance squared	-5.65×10^{-9}***
	(0.418×10^{-9})
common language	−0.1613***
	(0.0363)
$\log(X_h X_j)$	−0.1097***
	(0.0039)
regional border	−0.2101***
	(0.0511)
non EU border	0.1444***
	(0.0247)
Canada	−0.2448***
	(0.0752)
Spain	−0.4372***
	(0.0681)
Number of obs	984
R-squared	0.7536

Table 1: Regression results of log of δ with trade elasticity $= -3.5$

suggests that Canadian internal borders are less frictional than US internal borders, and the larger in magnitude negative coefficient on the Spain dummy, suggests that Spanish internal borders even less frictional than Canadian borders.

Note that the results in this table are highly dependent on the value of the trade elasticity, though the significance of each factor is insensitive to this parameter.

Figure 2 shows the measured values of the HRI, adjusted for the impact of physical distance and common language (i.e "log residual delta" is the log of the regression residual plus the impact of size and borders, and these are graphed against size), separating out the regions-rest of country pairs, EU country pairs, and other country pairs. As can be seen, the regional frictions are generally lower than EU frictions, which are generally lower than other country frictions. Figure 2 shows that regions have lower frictions than countries *conditional on size*. That is, any pair of countries is expected to have larger bilateral frictions than a pair of regions of the same size: there is something about being regions of the same country that is associated with a higher degree of integration than between equivalently sized countries (after controlling for physical distance and common language).

As discussed earlier, the Head Ries Index trade frictions measure will show a negative relationship with the size of the parties because it measures the frictions relative to internal frictions (and the larger the country, the larger the internal frictions, so the smaller the relative difference with

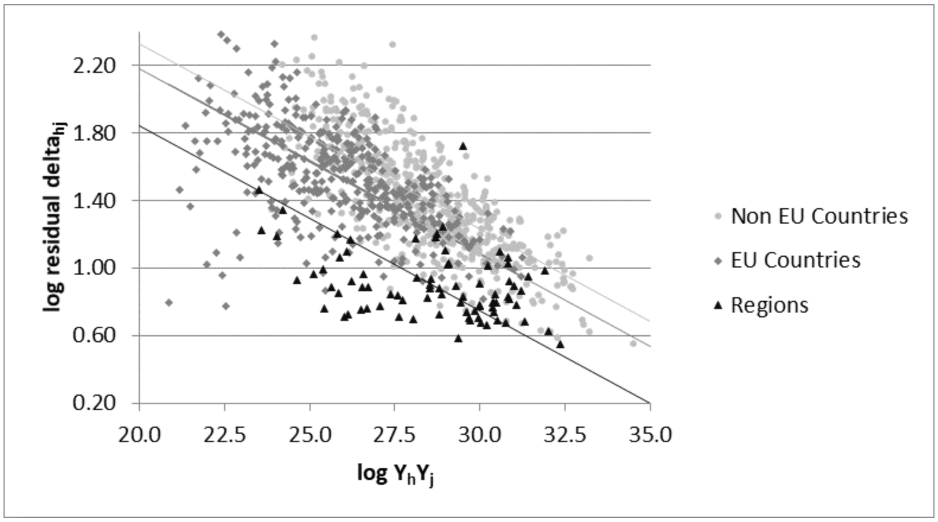


Figure 2: Scatter plot showing bilateral trade frictions against GDP split by countries and regions

external frictions). This does not impact upon our main point, since we report the average border effect *conditional on size*. We further investigate the systematic negative dependence in Appendix B where we demonstrate that this slope can be explained purely as a result of aggregation issues.

We define the "residual delta" in Figure 3 as the measured HRI after controlling for size as well as physical distance and common language. This figure shows that there is almost first order stochastic dominance for regional frictions compared with EU frictions, and likewise for EU frictions compared with other international frictions.

The difference between these CDFs is another graphical representation of the border effect. The border effect is the fact that controlling for size, physical distance, and whether there is a common language, the average international friction is larger than the average within-EU friction, which itself is larger than the average inter-regional friction.

In fact we believe that the average border effect is even larger than suggested by the coefficients in Table 1 due to the fact that we have evidence that trade in services is more home biased than trade in goods, and our data procedure has implicitly assumed that the degree of home bias is the same in both. We present this evidence in the next subsection.

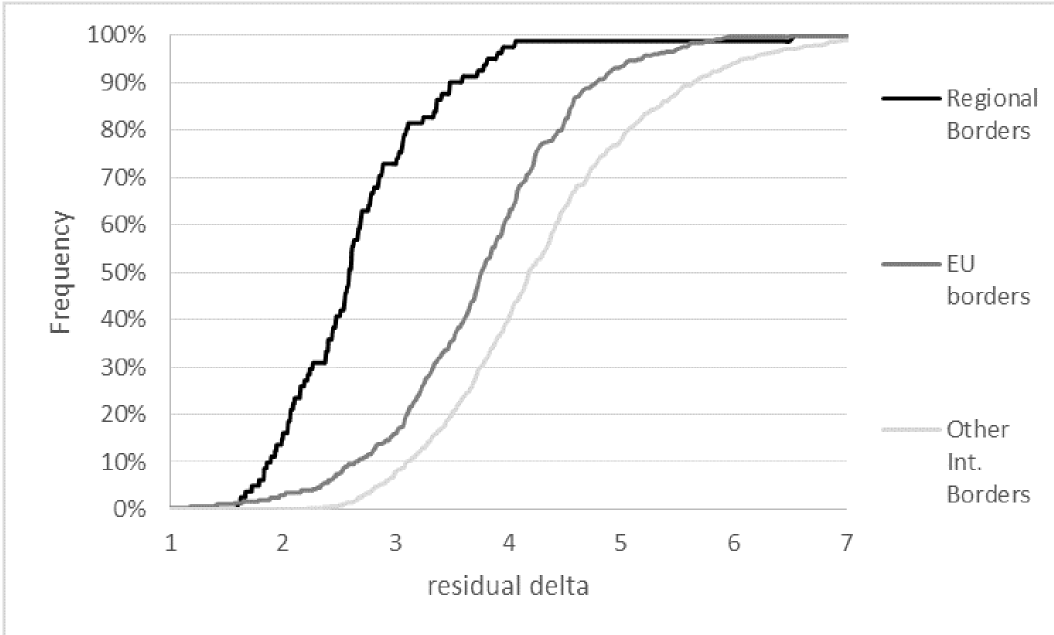


Figure 3: Empirical CDF of residual trade frictions between regions and between countries

2.3 Trade in Services

We have reason to suspect that this analysis is conservative due to the treatment of regional trade in services. The use of goods only inter-regional trade makes comparison between regional and country level frictions appear less stark than it actually is, and so is a conservative basis for conducting this comparison. The method we have used to determine a measure of internal and external trade for the regions that is consistent with the goods and services international trade matrix, given goods regional trade matrices, is valid if the degree of home bias in trade in services is the same as the degree of home bias in trade in goods. If services are more home biased, then our proceedure is conservative: it understates internal trade if there is more home bias in trade in services than in trade in goods.

We have goods and services trade data for the Canadian Provinces and for Catalonia and the Basque Country. Therefore we can calculate the HRIs based on both a goods only apportionment of the Canadian and Spanish trade data, and a goods and services apportionment of this data. In this way we can infer if the border effect is larger considering goods and services compared to goods only trade, and if so, how much larger. Table 2 shows the measured HRI based on a goods and services apportionment, and for a goods trade only apportionment. As we see, every single

Region	Natural Log of Measured HRI	
	Goods Only Data	Goods & Services Data
Alberta	0.888	0.729
British Columbia	1.075	0.837
Manitoba	1.035	0.886
New Brunswick	1.074	0.937
Newfoundland	1.140	1.014
Northwest Territories	1.460	1.195
Nova Scotia	1.176	1.006
Nunavut	1.456	1.264
Ontario	0.867	0.661
Prince Edward Island	1.353	1.185
Quebec	0.929	0.770
Saskatchewan	1.006	0.864
Yukon	1.670	1.353
Catalonia	0.618	0.548
Basque Country	0.641	0.640

Table 2: Measured HRI for regions when apportioning international trade by regional Ratio of internal to international trade for each region

region displays more home bias in its trade in services than it does in its trade in goods, and thus the frictions calculated under the goods only apportionment are higher in every case. The average of the log differences in frictions is 14%[18].

Every single region displays more home bias in its trade in services than it does in its trade in goods. Therefore, assuming that this is also true of the US states and the other Spanish Autonomous Communities, then the differences between regional and country level frictions are actually higher than the figures from Table 1. Assuming these results are representative and can be applied across the US States and the other Spanish Autonomous Communities, would imply that average differences in the log of regional and EU country frictions should be higher by an additional 14%.

It is therefore the case that the comparison of country frictions to regional frictions that we have performed, which shows significant differences even when controlling for obvious contributions to trade frictions, is a conservative comparison. A further case for the conservatism of the comparison that we do, is that sales across a border are more likely to be recorded and so we may expect any data quality issues to bias our results against finding significant differences between regional and country level frictions.

Summarizing. The body of evidence indicates that regional borders are systematically less

[18]The simple average difference is 17% while the average weighted by the size of the region-rest of country trade flow is 14%.

frictional than country borders: after controlling for physical distance and common language, for any given size, frictions are systematically lower among regions than among countries (Figure 2). Controlling for size, country frictions almost first order stochastically dominate regional ones (Figure 3). Taking into account the treatment of services increases this difference between regions and countries further. Our analysis is thus completely in line with other analysis that show that a substantial border effects exist: there is something that happens within countries that facilitates trade, something that does not happen across countries.

Furthermore, a similar, but smaller, effect is seen when comparing frictions internal and external to the European Union.

Nevertheless, the size of these effects dos not reflect the welfare gains of political union as there are obvious selection issues (of which regions form a country and which countries join the EU) to which we turn next.

3 Endogenous Country Formation

The estimated average difference between international frictions and interregional[19] frictions is large, but this does not mean that eliminating national borders would cause such a large fall in frictions. This is because who shares and who does not share a state is an endogenous proposition. Consequently, it is not obvious how to measure the trade enhancing value of sharing a state.

We have already seen that the measure of trade frictions is positively correlated with physical distance and with language differentiation. It is likely that it is positively correlated with all measures of population heterogeneity, and therefore in models of endogenous country formation such as Alesina, Spolaore, and Wacziarg (2005), it would be those pairs who already have a low trade friction that would select into sharing a state. This means that the average difference between international and interregional frictions overestimates the causal effect on trade friction reduction of sharing a state, and thus would overestimate the economic gains from political integration for an average pair of countries. Given a relationship between low frictions and selection into state

[19]For easy in exposition in this section we frame discussion in terms of the region versus country border effect. Notice though that exactly the same arguments apply in considering the impact of trading blocks like the European Union.

sharing, the econometric estimate for the Regions dummy in Table 1 will be biased towards being too large (in absolute value).

Suppose that the observed frictions between two entities h and j are a function of intrinsic characteristics of these regions and of whether they share a political union. We call their innate characteristics as θ_h and θ_j respectively. We denote whether h and j are part of the same country (political union) by s_{hj}. We say that $s_{hj} = 1$ if they are, and $s_{hj} = 0$ if they are not, part of the same country. The innate characteristics of the entities, θ_h, refer to cultural, social, geographical aspects that escape economic modelling and that we take as exogenous. These are things that we assume are not altered by trade or by sharing a political union.

It is reasonable to imagine that the frictions between h and j are a function of both entities' characteristics and of whether they share a national-state:

$$\ln \delta_{hj} = F(\theta_h, \theta_j) + \gamma s_{hj} + u_{hj} \tag{5}$$

where γ would be the effect of economic integration, and u_{hj} is some noise.

If θ_h and θ_j are independent of s_{hj} there is no problem with the estimation of equation 5. This is, loosely, what is shown in Table 1, where $F(\theta_h, \theta_j)$ is the geographic distance between h and j, common language, etc.

The estimation conducted to obtain Table 1 has two problems, the first trivial but the second potentially important. The trivial issue is that in our RHS variables we include only a small subset of the factors θ that may affect trade. It is trivial because, insofar as those missing characteristics are orthogonal to s_{hj}, the estimation of γ remains unbiased.

The substantial problem is that those characteristics (missing or not) are very likely to be correlated with s_{hj}: which entities select into being a country is far from an exogenous proposition. The probability of the event $s_{hj} = 1$, is very dependent of the affinities and similarities between the parties. Moreover, these similarities and affinities are also very likely to affect the frictions irrespectively of the value of s_{hj}.

Thus, when we see that regions trade more than countries, this could indicate either that sharing a political union is a trade-enhancing "technology", or that regions are regions (and not countries in our parlance) for precisely the same reason that they have high levels of bilateral trade: they have deep and special affinities. This is, the probability of $s_{hj} = 1$ is a function of $F(\theta_h, \theta_j)$.

$$Prob(s_{hj} = 1) = G(F(\theta_h, \theta_j))$$

In this case the OLS estimation of γ would suffer from upwards bias.

Given that the problem lies in determining the function $Prob(s_{hj} = 1) = G(F(\theta_h, \theta_j))$, an intuitive approach for solving this problem is to look at the break-up of nations. Head, Mayer, and Ries (2010) look at the erosion of colonial trade linkages after independence, and find a large fall in trade: on average, bilateral trade is reduced by more than 60% after 30 years of independence. However, colonies are unlikely candidates for economies who self-selected into an empire because of low initial frictions and similarities. Rather these were enforced partnerships that reflected a large difference in power.

Another possibility is to look at the break-up of countries in the former communist Eastern Europe. The obvious examples are the break-ups of Yugoslavia and Czechoslovakia[20]. However this is not a promising approach because the dynamics can of course be highly idiosyncratic: in Yugoslavia there was a war; and in any case they occur over timescales in which structural change, that is not orthogonal to independence, occurs. The set of events comprising the fall of the Soviet Union, the break-up of the states of the Warsaw Pact, the end of a centralised economy, and the subsequent membership for the new states into the EU, are not independent events and their effects can be conflated.

In order to deal with this endogeneity, one could look for sources of exogenous variation (for example Redding and Sturm (2008) use distance from the East-West German border to quantify the effect of integration on city growth, and Egger and Lassmann (2015) use regions on the internal Swiss language borders to quantify the effects of a common language on trade) but it is hard

[20]Following the so-called "Velvet Divorce" of 1993, the share of bilateral trade in total trade fell dramatically, with the share of total Czech exports going to Slovakia going from 22% to 8%, and the share of total Slovakian exports going to the Czech Republic going from 42% to 13%. This is not likely simply due to the opening of trade with the rest of the world following the fall of the Iron Curtain. The same source suggests that the share of trade between other neighbours from the Eastern bloc, e.g. Poland and Hungary, held up much better, or actually increased, following the opening up to trade with the rest of the world. HMTreasury (2013).

to imagine what exogenous variation we could exploit in the case of political integration. Our approach to control for this endogeneity is (at least in spirit) a form of regression discontinuity analysis which attempts to locate quasi-experiments. The difference is that instead of looking at state-disolutions and break-ups, we try to identify what we label as *"marginal regions"* and *"marginal countries"*. These are regions of a larger country that could conceivably be independent, and independent countries that could easily be regions of the larger country. Let h be such a marginal region, j be the associated marginal country, R be the country of which h is a part, and r be the rest of this country other than h (this is, $R = r \bigcup h$) . Then our assumption is that $F(\theta_h, \theta_r) \approx F(\theta_j, \theta_R)$ and thus, $\gamma \approx \ln \delta_{jR} - \ln \delta hr$. That is, the observed difference in frictions between such entities should be not dissimilar to the friction reduction that is caused by state sharing. In spite of working with only a small number of examples, we arrive at a conclusion that seems very consistent.[21]

We define *"marginal regions"* as regions within the EU with a strong and credible independence movement. There are three such regions in our dataset: Scotland, Catalonia, and the Basque Country[22]. We present a methodology for determining the best counterfactual to their trade frictions with the rest of the country to which they belong, using what we label as the *"marginal country"*. We define this as the country in the data with the lowest measured bilateral friction with the country that would be broken up upon an independence event.

This generates reasonable and interesting examples. We will conduct this exercise in Section 4, but to give an example of our results, Ireland is determined as the marginal country with respect to the UK, and therefore functions as the counterfactual for Scotland. The measured frictions between Ireland and the UK represent a much smaller increase to Scotland's measured friction with the rest of the UK than the econometrically determined average estimated in Table 1. It does not seem reasonable to increase the frictions that Scotland has with the rest of the UK by the average

[21] In any case, the traditional time series approach does not have many other observations either, as the number of informative instances of country break-up is also extraordinarily small (despite the large increase in membership of the UN - which is in large degree explained by decolonisation).

[22] On 18th September 2014 Scotland held an independence referendum in which 45% voted for independence. The Catalan government in the last few years has made an open push for independence. In recent elections and polls the pro-independence parties typically get 44% to 50% of the vote and they have a majority of the Catalan Parliament. In the last elections in the Basque Country 25% of the votes went to a very openly pro-independence party and a further 35% to a party with serious pro-independence inclinations.

difference between regional and country frictions when this results in higher frictions than we see for UK trade with other partners in the data. There are many special affinities between Scotland and England that it is unreasonable to suspect that all would disappear in the hypothetical case of independence. And if they do not all disappear they would be fostering trade between Scotland and England to levels that you would not expect between England and (say) Finland. The causal effect of a national border between Scotland and the rest of the UK is whatever is left beyond those special affinities that would not disappear. In other words, we have controlled for the selection bias on which entities are accounted into the labelling of "countries" and "regions" to the extent that Scotland and Ireland are otherwise identical vis-à-vis England.[23]

Thus, we do **not** propose to increase the magnitude of the frictions by the extra bit that regions add on **average** once we control for language, distance and size. Our proposal is to use as a counterfactual the **lowest** friction that we observe in the data that the country has with others. In the next section we use a structural trade model to evaluate the impact that this conterfactual experiment has upon income, and label this as the gain from the economic integration: it is closer to the **causal** impact of sharing a state.

Notice also that this methodology is used to provide an estimate of the gains from economic integration (joining a shared political space) and the costs of economic disintegration (leaving a shared political space). We assume that it can be applied symmetrically to both the creation and the elimination of borders. The estimate obtained mitigates the endogeneity problem of selection into a shared political space, is thus closer to an estimate of the causal effect of sharing a political space, and it should be applicable in non-marginal cases. So for example, the difference between the Scottish and Irish trade frictions with the (rest of the) UK could be applied to Finland's frictions with the UK to model a hypothetical political integration of Finland with the UK. This would increase Finnish-UK trade, but not to a level similar to that of Scotland's trades with the rest of the UK, because Finland is not a *"marginal country"* with respect to the UK, as Finland does not have the same affinities with the UK as Ireland does. Nevertheless, this increase in Finnish-UK trade is our best estimate of the impact of any putative political integration between Finland and

[23]In Appendix H we use the results obtained in Section 4, illustrated using the Scottish example, to suggest that there is an additional purely economic incentive for regions with low trade frictions to integrate (this is additional to affinities being a common factor in explaining both low trade frictions and propensity to integrate politically).

the UK. In the long run perhaps economic integration would harmonize these affinities, but this is outside the scope of our exercise. We take affinities as exogenous. In this sense we may be underestimating the impact of economic integration, but we have no way of dealing with this, and in any case we would be talking about the *very* long run here.

Further, in the long run steady state, it seems reasonable to us that the impact of creating or eliminating borders should be symmetric. However, this does not imply that the dynamics are symmetric, and for example it is possible that creating borders could be disruptive with large short run effects overshooting the steady state impact, whereas eliminating borders may have little short run impact with a slow approach to the steady state. We have nothing to say on these dynamics. They are extremely interesting, but beyond the scope of our analysis.

4 Counterfactual experiments on regional borders

In this section we evaluate the welfare consequences of policy experiments applied to the *"marginal regions"* of Scotland, Catalonia, and the Basque Country. We evaluate the cost to these regions of having international borders (though still within-EU borders) with the rest of the country of which they are part, both using the average econometric estimate, and using our *"marginal country"* counterfactual. Our counterfactual approach has a lower impact than imposing the average difference between country level and regional frictions but, as discussed, the comparison between marginal regions and the most closely integrated independent countries is much more informative as to the value of the extra economic integration that comes with political integration. The first measurement of the border effect by McCallum (1995) showed it to be extremely large. By incorporating economic theory to the analysis, Anderson and van Wincoop (2003) reduced the measured effect. By controlling for selection bias we further reduce its importance, but in this section we show that it is still quantitatively significant. As we shall discuss, we present a result which is insensitive to parameters (trade elasticity) and independent of model specification within a large subset of the gravity class of modern trade models. We show that the gains from economic integration that come with political integration are worth between a third and a half of the total gains from trade, relative to autarky, enjoyed by the regions that we consider.

Our procedure will be the following:

1. We calibrate a standard model to the data to obtain the implied frictions δ_{hj} that the model needs to assign in order to explain trade patterns between pairs.

2. We find suitable "marginal regions" and "marginal countries" and thus obtain the frictions of each "marginal region" and "marginal country" with the rest of the country to which the "marginal region" belongs in the data. We call these δ_{hr} and δ'_{jR} for marginal region and country respectively.

3. We go back to the model, and in place of the friction that the "marginal region" has with the rest of the country to which it belongs in the data (δ_{hr}), we substitute the friction that the "marginal country" has with the country to which the "marginal region" belongs (δ'_{jR}).

4. We thus evaluate GDP and trade patterns of the "marginal region" under this counterfactual.

5. We finally compare these results with the ones that we would get if, in place of the friction between the "marginal region" and the rest of the country to which it belongs in the data (δ_{hr}), we substituted the frictions implied by the econometric exercise of Section 2.

4.1 Model Solution and Calibration

In order to ilustrate the exercise that we perform, we use a specific model (a very standard trade model), but it is important to notice that our results would be identical for a much larger class of models. As we will remark later, Arkolakis, Costinot, and Rodríguez-Clare (2012) show that there exists a wide class of models (all of which generate a gravity equation), which happens to be the vast majority of models in normal use, with which identical gains from trade would be evaluated. Our model belongs to this family, so in spite of using this specific model to perform the exercise and illustrate the results, our results are not contingent upon this specific model. Identical results would be obtained using a modern Ricardian model in the spirit of Eaton-Kortum, or a model of intra-industry trade with heterogeneous agents in the spirit of Hopenhayn-Melitz.

Formally, we use an Armington model with intermediate goods, where frictions are a iceberg cost in moving either final goods or intermediate goods between the parties. We develop the model in detail in appendix C and here just present the fundamentals of the model and summarize its solution.

- Agents preferences are determined by a CES aggregation of goods produced in all locations, with elasticity of substitution σ: $U_j = \left[\sum_h c_{hj}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$, where c_{hj} is consumption of good manufactured in h and consumed by an agent in j.

- Production takes place in every location with a Cobb Douglas function using intermediate inputs produced in all locations and labor. β is the share of intermediate goods in production, and locations differ in the productivity of their labor and their size, which is summarized in their supply of effective labor (S_j). Thus, the total amount of good produced in location j is $S_j^{1-\beta}\left(\left[\sum_h i_{hj}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}\right)^{\beta}$, where i_{hj} are the goods made in location h and used as intermediate inputs in location j.

- There is an iceberg cost. The goods produced in any location h are used in any other location j as either as intermediate inputs i_{hj} or consumption c_{hj}, but in order to get one unit of good from h to j one has to ship $\delta_{hj} \geq 1$ units of which $\delta_{hj} - 1$ get lost on the way. Along with the bulk of the literature we assume that there is no iceberg cost when trading with yourself ($\delta_{jj} = 1 \quad \forall j$) and that frictions are symmetric ($\delta_{hj} = \delta_{jh} \quad \forall h, j$)

In the equilibrium of the model thus described, there is a gravity equation of the form:

$$X_{hj} = \frac{1}{1-\beta} \frac{Y_h Y_j}{(D_h D_j)^{\frac{1}{2}}} \delta_{hj}^{1-\sigma}$$

where X_{hj} are the (nominal) exports from h to j, Y_j is nominal GDP of location j and D_j is a term which in the trade jargon is referred to as *"multilateral resistance"*.[24] Taking logs of this gravity equation reveals that the trade elasticity, ϵ, in this model is $1 - \sigma$.

In order to calibrate the model we find the values of $\{\delta_{hj}, S_j\}\ \forall h, j$ such that for a given value of σ, and using $\{\delta_{hj}, S_j\}\ \forall h, j$ as parameters, the model generates values of X_{hj} and Y_h that match the data.

[24]Formally, in our model $D_h = P_h \sum_k \left(\frac{P_h}{P_k}\right)^{-\sigma} \delta_{hk}^{1-\sigma} \left(\frac{Y_k}{P_k}\right)$, where P_h is the price index for location h (everything is denominated in a common currency, say dollars)

In appendix C we present the detail of this exercise. It is important to remark the following result:

Result 1 (HRI are frictions)**.** *Equilibrium exports and GDP are such that* $\delta_{hj} = \left(\frac{X_{hj}^2}{X_{hh}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}}$

This is, *in the model* the Head Ries Index is identical to the frictions (iceberg cost) between locations. Consequently, when the model is calibrated to the data the value that the model assigns to the trade frictions between any pair h, j is *exactly* the HRI for that pair that we have calculated in Section 2. Moreover, this is true not only for our model but for a much larger family of models, essentially those that generate a gravity equation, as shown in Head and Mayer (2014).[25,26]

Thus, we use the model in order to map from the data (all trade flow and GDP data) into the parameters of the model: values of effective labor in all countries[27] $\{S_j : \forall j\}$ and bilateral frictions between any pair $\{\delta_{hj} : \forall h, j\}$. To do so we assume a certain value of the elasticity of substitution, σ. Specifically we use $\sigma = 4.5$ so that the value of the trade elasticity, $\epsilon = 1 - \sigma = -3.5$ (as in section 2) consistent with the standard values for the trade elasticity derived in Simonovska and Waugh (2014). In any case we will show that our qualitative results are independent of the value of σ used. Thus, we can think of this calibration procedure as an algorithm mapping data into parameters.

Let us remark on what our procedure is here. Given a set of parameters the model produces a set of simulated data. The parameters that we get from the calibration are those for which the "simulated data" is exactly equal to the real data as there is a unique mapping from the data to the parameters and vice versa. Moreover, we can do counterfactual exercises by changing parameters in the model from those implied by the data. Counterfactual parameters generate counterfactual GDP, which allow us to analyze the welfare impacts of such an exercise.

[25]For instance, Comerford, Myers, and Rodríguez-Mora (2014) perform a similar exercise with a Melitz model and Caselli, Koren, Lisicky, and Tenreyro (2017) do it in a Eaton-Kortum model. As their models have a gravity equation, they all get the same relationship between the HRI and frictions.

[26]Note further that while Result 1 is not *our* result and is ubiquitous across the literature, it is an important result to establish for our exercise. This is not only to tie together the model used in this section with the trade frictions used in the econometric exercise of Section 2, but also to establish the validity of our counterfactual experiment exercises. It is vital that we are imposing counterfactual model parameters rather than endogenous objects. The HRI defined in terms of observed trade flows maps onto the exogenous, parametric iceberg costs in the model, and not into any function of equilibium prices etc. Therefore it is a suitable object with which to perform counterfactual experiments in the model.

[27]Which measures the size and productivity levels in each location.

4.2 Determining Counterfactuals

In principle we could perform our exercise with any region for which we have regional trade data available. Nevertheless, it seems more reasonable to do it for those regions that could plausibly become an independent countries given the current political realities. Thus, we use as "marginal regions" Scotland, Catalonia, and the Basque Country. We have detailed regional data, including trade in services, for the three of them as described in Appendix A.

We will use two sets of counterfactuals.

Firstly, we perform what we deem the "marginal" counterfactual exercise. It consists of identifying the least frictional trading partner (lowest measured HRI) of the country to which the marginal region belongs, the "marginal" country. This is, we identify the country with the lowest frictions vis a vis Spain (as a counterfactual for both Catalonia and the Basque Country) and the UK (as a counterfactual for Scotland). These countries are Portugal and Ireland respectively.

The fact that the counterfactual trading pairs are similar in size to the trading pairs upon which we are conducting these policy experiments gives further validity to these counterfactual exercises beyond their intuitive appeal. In any case (in particular, with respect to size, for the case of the Basque Country) we adjust the implied counterfactual frictions of the "marginal country" by size and distance using the coefficients estimated in Section 2.[28]

Let h be the region, j be the counterfactual, R be the country of which h is a part, and r be the rest of this country other than h. We measure δ_{hr} and δ_{jR} from data using the model, and then define δ'_{jR} by adjusting δ_{jR} for size and distance using the difference in size and distance between our "marginal region" and "marginal country" and the coefficients in Table 1.

Our second set of counterfactuals is the one derived from running an econometric exercise, increasing the value of δ_{hr} by the amount obtained in table 1. We call this the "average" counterfactual scenario (δ_{hr}^{ave})

We calculate the "Average Impact" (δ_{hr}^{ave}) as the measured HRI for the Region-Rest of Country

[28]The adjusted counterfactual could also control for language. We opted not to do so as both Catalonia and the Basque Country have their own languages, as Portugal does, and in both Ireland and Scotland their own languages are extremely minoritarian. Nevertheless we performed the same exercise assigning different language to Portugal and Spain but the same language between Catalonia and the rest of Spain, which could be thought as the more complicated case on this respect. To do this does not change the results in any significant manner, see footnote 31.

pair adjusted by the average border effect in table 1, as well as by the 14% trade in services impact from Table 2. For Catalonia and the Basque Country, we augment it further by the observed by the Spain fixed factor in table 1.

The marginal counterfactual implements the discussion of Section 3: this is our proposed correction for the endogeneity of country formation which will bias the econometric estimates that determine the average counterfactual.

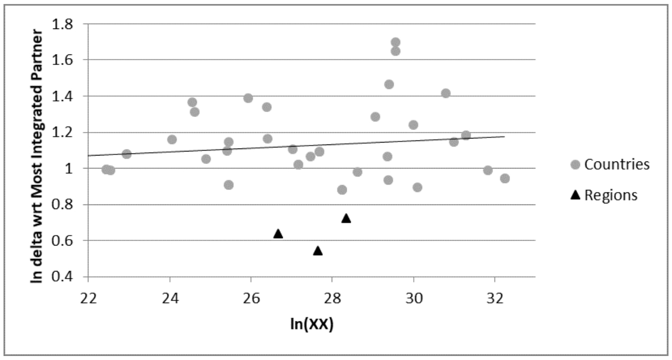
4.2.1 No Substitution

Before we conduct our policy experiments, we consider another reason why the difference between international and inter-regional frictions (both calculated as the econometric average, or as the difference between marginal countries and marginal regions) could over-estimate the impact of political integration upon economic integration. It could be thought that regions have lower frictions with the rest of the country to which they belong *at the expense* of larger frictions with the rest of the world. This "substitution" in frictions could in principle be a reflection that close ties with a partner foster close links with it, but by not interacting with others, you get further apart from them. In such a case the role of political integration for fostering trade integration could be overstated, even with our way of controlling for endogeneity of country formation.

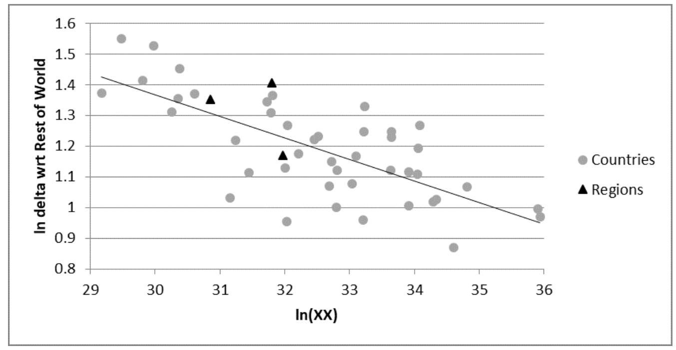
We investigate this by looking at the three marginal regions of our dataset within a "three country" framework: the multilateral dataset is aggregated up in each case so that we are considering the three by three trade matrix involving the region, the rest of its nation, and the rest of the world. The results of doing this are compared against the equivalent for every country in the dataset, where the three by three trade matrix now involves the country, its most integrated trading partner (lowest measured frictions[29]), and the rest of the world. The results are presented in Figures 4a and 4b. We can see that the regions have roughly the expected level of trading frictions with respect to the rest of the world, but lower than expected frictions with their most integrated trading partner (which is the rest of their nation).

In the data, regions differ from countries in the frictions that they have with their main partner,

[29]We do this after controlling for size since the negative relationship between size and frictions is an aggregation issue (see Appendix B) rather than a real feature of close integration.



(a) Regions are better than expected at trading with their most integrated trading partner



(b) Regions do not seem to be any worse than expected at trade with the rest of the world

Figure 4: HRIs with main trading partner and with rest of the world

not in the frictions that they have with the rest of the world. We do not find that our marginal regions are systematically less integrated into the global economy than are independent countries of the same size. It does not seem to be the case that regions get their extraordinarily low frictions with the rest of their country at the expense of larger frictions with the rest of the world. Instead, the close economic integration across regional borders is on top of normal trade links with the rest of the world. Thus, there is no reason to think that altering the political integration of a region with the rest of the country to which belongs would alter the frictions with the rest of the world.

4.3 Counterfactual Experiments

In Table 3 we perform our first set of counterfactual experiments. The first set of columns (headed "Trade Frictions") show the frictions that we will use to perform the experiments. The first one shows the friction between the "marginal region" and the rest of the country where it belongs (δ_{hr}). The second column shows the friction of the "marginal country" with the country of which the region is part (δ'_{jR}). Finally the third column shows the friction between the "marginal region" and the rest of the country to which it belongs when augmenting δ_{hr} by the econometric value of not sharing a state (δ^{ave}_{hr}).

The second set of columns shows the welfare impact (change in real GDP) on each "marginal region" of imposing δ'_{jR} (our marginal counterfactual) and δ^{ave}_{hr} (our average counterfactual), leaving all other parameters constant.[30]

[30]Every figure in this Table 3 is of course sensitive to the value chosen for the trade elasticity, here $\epsilon = 1-\sigma = -3.5$ as previously.

	Measured Trade Frictions (HRI)			Welfare Impact of Counterfactual	
				"Marginal"	"Average"
	δ_{hr}	δ'_{jR}	δ_{hr}^{ave}	δ'_{jR}	δ_{hr}^{ave}
Scotland (Ireland)	2.067	2.707	2.947	-8.5%	-9.8%
Catalonia (Portugal)	1.730	3.990	3.819	-12.5%	-13.7%
Basque C. (Portugal)	1.897	3.066	4.189	-15.9%	-18.3%

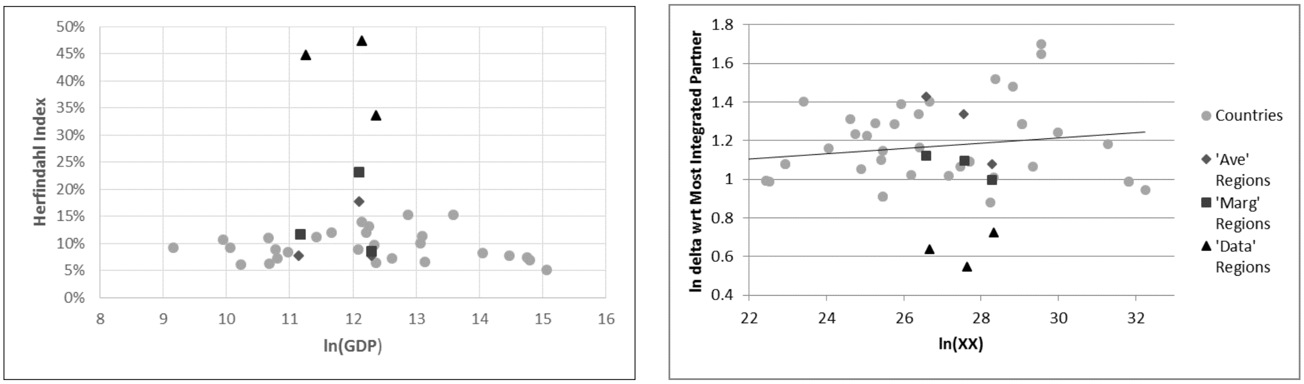
Table 3: Counterfactual Experiments, with trade elasticity $= -3.5$

For example, in the first row we look at the effects of substituting the frictions that Scotland (the "marginal region") has with the Rest of the UK (δ_{hr}) for *(i)* the frictions that Ireland (the marginal country) has with the UK (δ'_{jR}), and *(ii)* the frictions that we would impute to the Scotland-UK border if instead we were to use as a counterfactual the average effect from the econometric exercise of Table 1 (δ_{hr}^{ave}). The welfare change derived from these two exercises are displayed in the fourth and fifth column respectively. In both counterfactual exercises the productivity of workers in Scotland, the rest of the UK and the rest of the world is kept constant at the same level that we obtain in our calibration of the data. Likewise, the bilateral frictions between all pairs except the one for which we perform the experiment are also kept constant at the value assigned in the calibration. The following two rows perform the same exercise for Catalonia and the Basque Country using Portugal as their marginal country.

Before discussing the results it is interesting to notice that our marginal counterfactual seems to generate reasonable artificial economies. As we have seen the trade patterns of our marginal regions do not look at all like the trade patterns of independent countries with the same size, as evidenced in figures 1b and 4. A reasonable counterfactual demands that once the political ties are severed, the resulting simulated economies generate trade patterns that could reasonably be drawn from the same distribution than the ones observed in the data: our exercise consist in making the regions look as normal countries.

In Figure 5b we augment Figure 4 with the frictions of our counterfactual exercises. Clearly, in the data the regions are unusual, but the imputed values in our counterfactuals (particularly in the Marginal case) are within the range of normal.

In Figure 5a we show the Herfindhal Index of trade concentration in the data and in our



(a) (b)

Figure 5: *Herfindahl Index of trade concentration and HRI with main partner as a function of size. Plots the values in the data and in our counterfactual exercises.*

simulated economies under both counterfactuals. The exceptionality of the regions disappears in our counterfactual experiments: they look like the other countries. If anything, in the marginal counterfactual, the relationship between (say) Scotland with England is still a bit more special than what you normally find between countries (due to their special affinities, independent from political arrangements), but in the ballpark of normality.

Thus, we have established that our counterfactuals, especially the marginal counterfactual, are a good approximation to the effects of severing political ties. There is a set of very clear and interesting lessons that can be learned from performing these experiments.

Result 2 (Endogeneity Correction)**.** *The frictions of our* "marginal" *counterfactuals are lower than those implied by an econometric exercise that produces average effects.*

This is the sense in which our exercise corrects the selection bias. It would not be reasonable to expect that after a hypothetical Scottish independence, that the trade frictions between Scotland and England were to become as large as the ones that the UK has with the average of its other trading partners. The welfare impacts based on the counterfactual marginal countries are consequently lower than the impact of imposing the average difference between country and regional frictions.

Result 3 (Large Gains of Integration)**.** *Once we control for endogeneity of country formation, the remaining gains for trade associated with sharing a national state are still very large.*

Even after controlling for the deep affinities between places by assigning as a counterfactual the lowest relevant frictions observable in the data (the "marginal country"), it seems to be the case that sharing a state is a very powerful trade enhancing technology.

In Table 3 (contingent upon a value of $1 - \sigma = -3.5$ as before) the losses associated with the breaking up political ties are 8.5% for Scotland, 12.5% for Catalonia[31] and of 16% for the Basque Country. These numbers, albeit smaller than the ones generated by the average counterfactual, are still extremely large.

They come as a consequence of the loss of the ability to trade with a partner at an extraordinary low friction. At such a low friction the economy concentrates its trade with such a partner to an extraordinary degree. Once that political link is cut, the trade between both is still very large, as they are still the partner with the lowest frictions. Nevertheless the frictions in the marginal counterfactual are much larger than before, and this translates into a massive change in trade patterns.

The economy of the "marginal region" did enjoy a diversified consumption at a low cost, and with an elasticity of substitution of 4.5 this amounts to a large gain. Notice that it is just *the difference* in the frictions *with the main partner* (in the case of Scotland moving from 2.067 to 2.707) what produces this gain. This is because this increase (in this case of 0.640) does not happen with any random partner, but with the one with whom you had an extraordinarily profitable relationship, and where, as a consequence, you were concentrating the bulk of your trade. Once this extraordinary relationship disappears, your trade with this partner, being large falls into the range of the usual. The loss is partially compensated by an increase in exports and imports with the rest of the world[32] (but that involves paying a large trade cost, which makes it less profitable) and for an increase in domestic sales[33] (but where you do not enjoy the benefits of diversification and increased variety). These can not compensate, in welfare terms, for the loss of the exceptionally low frictions.

[31] When we adjust the frictions including a "same language" dummy for Catalonia, the associated loss is 12% instead.

[32] The ratio of trade with the RoW to GDP moves from 25% in the data to 28% in the "marginal counterfactual"

[33] They move from 68% of gross output in the data to 78% in the "marginal counterfactual".

4.4 Generality of the results

There are two assumptions that we have made that could, in principle, affect our findings: we have used a specific model, and we have assumed a certain value for the trade elasticity. Next we show that (i) all models that generate a gravity equation (arguably the vast majority of trade models) would generate the same results that we find, and (ii) that our qualitative results are very stable and unaffected by the elasticity that it is assumed.

4.4.1 Model Selection

In a very influential paper Arkolakis, Costinot, and Rodríguez-Clare (2012) have shown the remarkable result that conditional on the elasticity of trade to frictions (ϵ in our parlance), the gains from trade are the same in a large set of models: all those that generate a gravity equation. This is, how much does one benefit from having lower frictions is the same number in all models that belong to this family *given a value of* ϵ. Clearly, in different models the explanation of why you gain from trade is different, but in all of them you end up with the same measured gains.[34,35]

For instance, the Eaton-Kortum model is a modern version of the Ricardian model, and it generates a gravity equation. Consequently, one can interpret the gains from trade as the gains from consuming diverse products while specializing in the production on the ones in which you have comparative advantage.

On the other hand, models of intra-industry trade in the Hopenhayn-Melitz tradition also generate a gravity equation. In this context the gains from having lower frictions with other location arise from a totally different mechanism. Lower frictions imply more competition with foreign producers and allows the more efficient local producers to export more, increasing their profits, and increasing their demand for inputs. The less efficient local producers find themselves trapped between increased foreign competition pushing down prices for their output, and increased domestic competition from efficient local producers pushing up prices for their inputs. Trade

[34] Whether the gains are exactly the same is conditional upon some elements of the model like the inclusion or otherwise of trade in intermediates, multiple sectors, etc, as described in Arkolakis, Costinot, and Rodríguez-Clare (2012).

[35] For example, Comerford, Myers, and Rodríguez-Mora (2014) used the basic Melitz (2003) model (which is in the general class of models described in Arkolakis, Costinot, and Rodríguez-Clare (2012)) as well as using older data, and obtained very similar results.

improves welfare as it improves the quality of firms: it works as an increase of competition.

The beauty of the ACR result is that it recognises that both these model generate a gravity equation of the same form - though with an entirely different structural interpretation on the elasticity of trade to frictions. The implication is that given any specific value for this elasticity, both models would predict the same gains from trade for a given change in frictions, even if the reasons that they argue for the existence of those gains are completely different. All models within the ACR class of models generate the same welfare results, given a particular value of ϵ. Our model also generates a gravity equation and is within the ACR class. *Consequently all these models would generate the same results as generated by our model.*

In other words, you should not judge our results for the specifics of our model, except for the fact that it generates a gravity equation. All other models that do (Eaton-Kortum, or Melitz, for instance) would produce the same gains from integration.

4.4.2 Stability of Results to Parameter Selection

Going back to our results, notice that they are calculated assuming a trade elasticity of $\epsilon = -3.5$ (this is, a elasticity of substitution between goods of $\sigma = 4.5$) as suggested by Simonovska and Waugh (2014). If the elasticity of substitution were assumed instead to be very large, the effects of increasing the frictions with your main partner would be small, as you could simply substitute for goods from other countries, or from your own, without much cost. On the other hand, if the elasticity of substitution were much smaller, by increasing the frictions we would force a much larger cost due to the lost in variety in consumption: local goods are a bad substitute of external goods. The value of ϵ (and thus σ) that we have assumed is understood to be reasonable in the literature, but there are no certainties on this respect.

The magnitude of the gain from integration that we find would, thus, depend in an obvious manner of this assumption. Nevertheless there is an interesting sense in which our results are independent from the elasticity of substitution assumed.

Result 4. *The loss associated with the "marginal counterfatual" for the "marginal region" is between* $1/3$ *and* $1/2$ *of the total gains from trade that the marginal region has (relative to be in*

	Welfare Impact / cost autarky		
	$\epsilon = -2.8$	$\epsilon = -3.5$	$\epsilon = -5.2$
Scotland (Ireland)	39%	38%	38%
Catalonia (Portugal)	42%	42%	41%
Basque C. (Portugal)	48%	47%	46%

Table 4: Welfare changes as a proportion of overall gains from trade are insensitive to changes in the trade elasticity

autarky) irrespectively of the trade elasticity assumed.

In Table 4 we compare the loss derived from moving from δ_{jr} to δ'_{jR} for each "marginal region" (i.e. moving the Scotland-England friction to the same value as the Ireland-UK friction, but not moving the Scotland's friction with anywhere else) with the loss derived from moving Scotland into autarky. Autarky is calculated by moving the frictions that the "marginal region" has *with all other partners, not only with the rest of the country where it belongs* towards infinity (i.e. Scotland can not trade with England, or with any other place on Earth).[36] We perform this exercise for a range of values of the trade elasticity, and it is clearly noticable that the results are remarkably stable. Varying the trade elasticity makes trade more or less important for welfare, but it is always the case that the gains from trade associated with sharing a state are a fraction of between a third and a half of the total value of gains from trade relative to autarky.

This insensitivity of the results to changes in the trade elasticity is implied by insensitivity of trade flows to the elasticity as described by Section V of Anderson and van Wincoop (2003). Changing the trade elasticity will change the trade impact of a given change in frictions, or the welfare impact of a given change in trade. However, conditioning on a counterfactual which is based on an observation in the data means that different trade elasticities imply different changes in frictions such that the implied change in trade flows is not greatly affected. Further, whilst the welfare impact of this implied trade flow change is a strong function of the trade elasticity, it is a fairly constant proportion of the total gains from trade relative to autarky.

Thus, we can conclude that the gains from trade due to political integration into relatively larger political units accrue for a large percentage of the total gains from trade of regions, and this

[36]We show in appendix G that the welfare gains with respect to autarky can be expressed in a simple formula. As Arkolakis, Costinot, and Rodríguez-Clare (2012) show, this formula applies to all models generating a gravity equation.

is so irrespectively of the trade elasticity.

5 EU Integration and Brexit

In this section we look at the degree of integration that the EU provides, the potential costs of losing such integration and the potential benefits of furthering that integration.

We start by performing exercises similar to the ones of the previous section, the difference being that instead of looking at the creation of hypothetical internal borders within countries of the EU, we look at the effects of a hypothetical departure from the EU. Or perhaps not that hypothetical, as the UK voted to leave the European Union and is set to formally do so during 2019.

One could argue that augmenting the frictions between the UK and the rest of the EU by the average impact of EU membership on bilateral frictions estimated in the econometric exercise of Section 2, will overestimate the effects of Brexit for the same reasons that we exposed in section 3: Britain has belonged to the EU for 45 years *because* of the large degree of affinities with the rest of EU countries, and those affinities are not likely to disappear as a consequence of Brexit. We consider a set of counterfactual scenarios which are informative about the potential costs of Brexit.

We then consider the gains provided by the existence of the EU to its members, and what would be the costs of the dissolution of the EU.

Finally, and for the shake of completeness, we revisit the possibility of independence for Scotland under different hypothetical arrangements vis-a-vis the EU.

5.1 Brexit Scenarios

A difficulty in trying to make reasonable counterfactuals for the effects of Britain leaving the UK is the degree of uncertainty on the eventual arrangement. The costs are unlikely to be the same for staying within the single market (in an EEA type arrangement such as that of Norway), having extensive bilateral arrangements that amount to the same (as Switzerland does), or remaining within the customs union (Turkey has a customs union with the EU for manufacturing goods,

δ	Country	EU	δ	Country	EU	δ	Country	EU	δ	Country	EU
4.229	LUX	1	4.387	EST	1	4.519	PRT	1	4.968	KOR	0
4.241	HUN	1	4.402	POL	1	4.520	LVA	1	4.987	USA	0
4.247	MLT	1	4.422	LTU	1	4.525	CYP	1	5.006	CAN	0
4.289	BEL	1	4.456	DNK	1	4.538	FIN	1	5.056	MEX	0
4.298	CZE	1	4.462	CHE	0	4.550	ITA	1	5.100	CHN	0
4.307	SVK	1	4.469	BGR	1	4.555	ESP	1	5.100	BRA	0
4.313	NLD	1	4.470	SWE	1	4.565	GBR	1	5.122	IND	0
4.317	IRL	1	4.491	FRA	1	4.640	TUR	0	5.136	AUS	0
4.363	DEU	1	4.505	ROU	1	4.694	GRC	1	5.187	JPN	0
4.369	SVN	1	4.507	NOR	0	4.746	RUS	0	5.193	IDN	0
4.370	AUT	1	4.512	HRV	1	4.943	TWN	0			

Table 5: Residual Frictions with EU after controlling for size of both parties (residuals frictions with rest of the EU if the country belongs to the EU). Residuals frictions given by $\ln \delta - \alpha_{\ln XX} \times \ln XX$, where $\alpha_{\ln XX}$ is the coefficient on $\log (X_h X_j)$ from Table 1.

though not for agricultural products), as to having the same frictions that two (albeit good) neighbors who are simply both members of the WTO, would be expected to have. In order to clarify matters we produce a set of possible scenarios, measure their impact, and let the reader use their own criteria for evaluating how reasonable each of these counterfactuals are.

In Table 5 we order countries by their measured frictions with the EU, once corrected by size. If the country is a member of the EU, we report its frictions with the rest of the EU. There are two things to note in this table. First, notice that the UK is amongst the less integrated countries with the rest of the EU. The implied frictions with the rest of the EU are larger than for all other countries of the EU except Greece. Second, the non EU countries with the smallest frictions with the EU are Switzerland, Norway, Turkey and Russia (in that order) which makes some sense in terms of their degree of institutional integration with the EU.

As a matter of comparison, in Table 6 we present the result of some counterfactual exercises of the type that we performed in the previous section. Here we define *"marginal countries"* as non EU members highly integrated with the EU, and *"marginal regions"* as the EU countries which are their most natural counterparts. Notice that Austria "becoming like" Switzerland or Sweden "becoming like" Norway have relatively small (albeit not insignificant) effects on GDP (of course, they have larger effects on the size of trade flows with the EU). Poland "becoming like" Russia has much larger negative consequential effects. The case of Greece "becoming like" Turkey is somewhat surprising, since Turkey measured friction with the EU is lower than Greece's. We are skeptical about this last result, as it might be related to the specific economic circumstances of Greece since 2010, and in what follows we will ignore comparisons with Greece, and any consideration of Turkey.

Mg region⇒Mg country	$\delta_{hr} \Rightarrow \delta'_{jR}$	Welfare Change
Austria ⇒ Switzerland	2.654 ⇒ 2.852	−2.6%
Sweden ⇒ Norway	2.862 ⇒ 3.032	−1.5%
Poland ⇒ Russia	2.649 ⇒ 3.290	−5.4%
Bulgaria ⇒ Russia	3.596 ⇒ 3.593	+0.0%
Romania ⇒ Russia	3.278 ⇒ 3.474	−1.5%
Greece ⇒ Turkey	3.988 ⇒ 3.384	+3.3%

Table 6: Some Hypothetical exercises within the EU. Implied effect on GDP of the *"marginal region"* of substituting the frictions with the rest of the EU for the frictions that the counterfactual country (*"marginal country"*) has with the EU.

	Marginal Region	Marginal Country	log difference
Austria vs Switzerland	2.654	2.852	0.0719
Sweden vs Norway	2.862	3.032	0.0575
Poland vs Russia	2.649	3.290	0.2165
Bulgaria vs Russia	3.596	3.593	-0.0007
Romania vs Russia	3.278	3.474	0.0579
Mean Value			0.0736

Table 7: Frictions with the EU of selected countries along with the frictions with the rest of the EU of selected counterparts.

In table 7 we report the value of the frictions between *"marginal regions* and *"marginal countries"* in the European context. For Switzerland the natural choice is Austria, and for Norway it is Sweden. As discussed, we drop the Greece-Turkey comparison. The best counterparts for Russia are probably Poland, Bulgaria, or Romania. Notice that the mean differences in log frictions, 0.0736[37] is much lower than the average effect of the EU on log frictions, which is 0.1444 from Table 1. This is consistent with endogenous selection into the EU, and suggests that to imply an increase of frictions to be equal to the average effect of the EU on frictions as a consequence of Brexit could overestimate its effects, as discussed in section 3.

We define the *"marginal counterfactual"* experiment as an increase in the (log) frictions between the UK and the rest of the EU of 0.0736, which is the mean value from Table 7.

Alternatively, we define the *"average counterfactual"* experiment as an increase in the (log) frictions between the UK and the rest of the EU of 0.1444, which is the econometrically estimated value from Table 1.

In Table 8 we show that the *"marginal counterfactual"* experiment produces a fall of UK GDP of 1.0%, compared with a 1.7% fall suggested by the "average counterfactual" experiment.

Notice that the implied *"marginal counterfactual"* experiment does not take into account any of

[37] This is the mean of the figures for 'Austria vs Switzerland', 'Sweden vs Norway', and the mean of the three '... vs Russia' figures. The simple mean of all 5 figures is 0.0806.

Counterfactual	δ_{UK-EU}	Δ of log δ	δ'_{UK-EU}	Welfare Change
"Marginal Counterfactual"	2.668	0.0736	2.871	-1.0%
"Average Counterfactual"	2.668	0.1444	3.082	-1.7%

Table 8: Marginal and Average Counterfactual Experiments

the specificities of the relationship between the UK and the EU. In particular it does not account for the fact that the UK is a large supplier of financial services to the rest of the Union. Not only has the UK the largest financial sector share in GDP of all the G7 countries (and more than twice Germany's share), but the contribution of UK financial services exports to GDP is also the highest. This is a sector very sensitive to regulation, and the new political realities in Europe as a consequence of the UK not having political representation in the Union, open the possibility of regulatory changes likely to decrease the relative advantage that the UK has now in the sector. We have seen in section 2.3 that trade in services is typically much more home-biased than goods trade. It is likely to be the case that this is also the case across the EU border, particularly given that the political sphere for regulation in those matters lies in Brussels more than in country states. It seems reasonable to expect regulatory changes making it more difficult for the UK to export financial services to the EU once the voice of Britain ceases to be heard in Europe and once British interests are not accounted for in the EU political process. To properly account for those facts lies beyond the scope of this paper, but those realities should be taken into account when considering the possible consequences of Brexit.

An alternative, and perhaps more natural, counterfactual for the UK after Brexit are non European countries that share many cultural, social and political similarities with the UK. Countries like Canada, USA or Australia. A further natural counterfactual is Russia since post-Brexit, the UK and Russia will be the two large, culturally European, countries that border the EU. In Table 9 we present the results of the exercise of substituting the frictions that the UK has with the rest of the union by the frictions that USA, Canada, Australia and Russia have with the EU (after controlling for size and distance). The effects on UK's GDP range from decreases of around 1.1% (if the counterfactual is the USA) to 3.5% (if it is Australia).[38]

In Figure 6 we summarise these results and show how the welfare impact upon the UK of

[38]That this before the implementation of any possible free trade agreement between Canada and the EU

Mg region⇒Mg country	$\delta_{hr} \Rightarrow \delta'_{jR}$	Welfare Change
UK ⇒ USA	2.668 ⇒ 2.905	−1.1%
UK ⇒ Canada	2.668 ⇒ 3.674	−2.9%
UK ⇒ Australia	2.668 ⇒ 4.247	−3.5%
UK ⇒ Russia	2.668 ⇒ 3.024	−1.5%

Table 9: Counterfactuals for the UK outside Europe. Frictions of the counterfactual *"Marginal Country"* are corrected by size and distance.

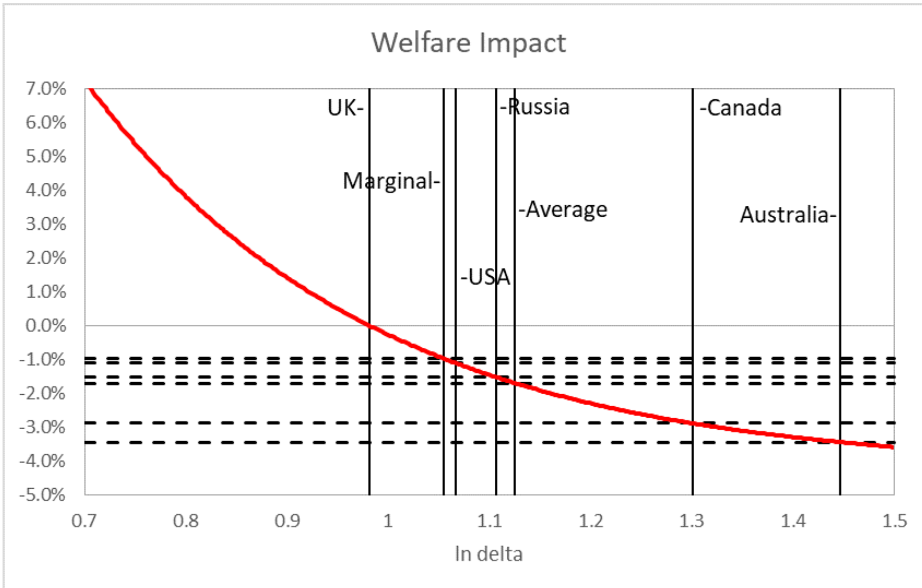


Figure 6: UK real income as a function of the trade friction with the rest of the EU.

Brexit depends on the frictions that the UK may have with the rest of the EU. There, we mark hypothetical values of δ and the corresponding welfare imapct upon the UK. The hypothetical frictions that we mark are (1) the frictions that the UK has currently with the EU. If these were to be the frictions after Brexit (i.e., no change at all in frictions), there would be of course no change in welfare. (2) The frictions resulting from adding to the UK-EU frictions, the *"marginal counterfactual"* described above, and the *"average counterfactual"* from Table 1. These result in a loss of about 1.0% and 1.7% of GDP respectively. And (3), the US-EU, Russia-EU, Canada-EU and Australia-EU frictions (all translated to the UK-EU friction by correcting for size and distance). Imputing these frictions to the UK-EU border would result in a loss to the UK of 1.1%, 1.5%, 2.9% and 3.5% of GDP respectively.

Thus, one can conclude that the steady state effects of Brexit on trade are likely to produce a significant, albeit by no means disastrous, reduction in British GDP ranging from 1.0% to 3.5%. Other more systematic and econometric estimates of the impacts of multilateral trading blocks have been conducted, that for example exploit the variation across time in entry and exit into trading arrangements (see e.g. Baier and Bergstrand (2007)). However, our analysis of this issue in the context of Brexit, produces results that are consistent with other economic estimates which have been generated: Sampson (2017) surveys the literature and finds that plausible estimates of the costs of Brexit to the UK lie in the range of $1\% - 10\%$ of GDP. For instance, Dhingra, Huang, Ottaviano, Pessoa, Sampson, and Reenen (2017) find that structural model estimates which only change trading frictions upon Brexit (such as those conducted in this paper) produce costs in the range $1\% - 3\%$. They also find that reduced form estimates (which may also reflect trade impacts upon productivity and technology, capital accumulation and FDI, and immigration) produce costs of Brexit to the UK in the range $6\% - 9\%$ of GDP. This is consistent with the arguments in Brooks and Pujolas (2017), which in a dynamic general equilibrium trade model produce larger gains from trade than estimates based on static models, due to the dynamic adjustment of capital. Other estimates of the costs of Brexit include those of Steinberg (2017), Ebell and Warren (2016) and Ebell, Hurst, and Warren (2016), who find impacts on GDP of $1\% - 4\%$.

Despite considering a number of counterfactual scenarios here to model the UK exit from the EU, none produce losses of the magnitude seen for the exercises in which regions became like countries. The impacts that we get are almost of an order of magnitude lower.

Result 5. *The welfare loss associated leaving the EU is much smaller than the welfare loss associated with regions becoming countries.*

5.2 The Aggregate effects of the EU

The fact that the magnitude of the effects of leaving the EU (from the previous section) are much smaller than the effects of regions becoming independent *and both parties remaining in the EU* (as reported in section 4) does not imply that the existence of the EU has small effects on welfare. In this section we perform counterfactual exercises showing (i) that the effects of the EU on welfare are considerable, particularly for small countries, but that (ii) the effects of decreasing the frictions within the EU to those in line with those that regions of the same country have between them could be extremely large indeed (again, particularly for small countries).

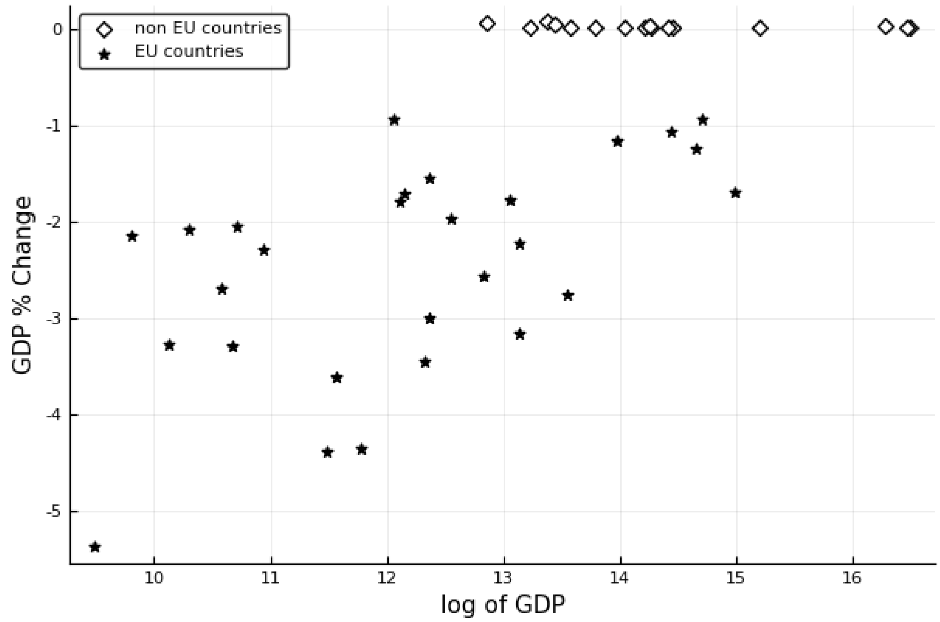


Figure 7: Welfare effects in all countries of increasing log δ of EU-EU borders by the *"marginal"* effect, +0.0736, of the EU.

We first do the exercise of considering that *all* the countries within the EU increase the frictions between themselves by the *"marginal"* effect that the EU has on frictions (i.e., an increase of the log δ_{hj} of 0.0736 for all country pairs where both i and j belong to the EU). This has three types of effects: (i) it obviously increases the frictions between the pairs, reducing their welfare, (ii) it produces general equilibrium aggregate demand effects, as the economies affected by the increase in frictions sum to a substantial amount of world GDP, and (iii) it produces a change in terms of trade benefiting non EU countries (whose goods become more demanded as former EU members have more difficulty trading among themselves). This sums to a decrease of World GDP of 0.3%, but this change is very unevenly distributed. Non EU countries have a very small increase of 0.01% of GDP, while EU GDP suffers a decrease of 1.7%. In Figure 7 we plot the effect for all countries along with the country size. For small European countries the loss is substantial (close to 5% in some cases) while for larger countries it is much smaller. In the case of the UK the implied loss is of 0.95%[39].

[39] The Brexit only loss for the UK is 0.97%. In the case of EU disintegration following Brexit, we can imagine the UK suffering the 0.97% loss on Brexit which is then followed by the disintegration of the EU. When the EU falls apart, the UK (which is already outside the EU) experiences two offsetting effects: the first is a further fall in GDP as its EU trading partners suffer a loss and demand from these countries falls; the second is a trade diversion effect - the EU countries used to trade more with each other, but as their borders become more frictional, some of these purchases are instead made from non-EU countries. The (positive) trade diversion effect dominates the (negative)

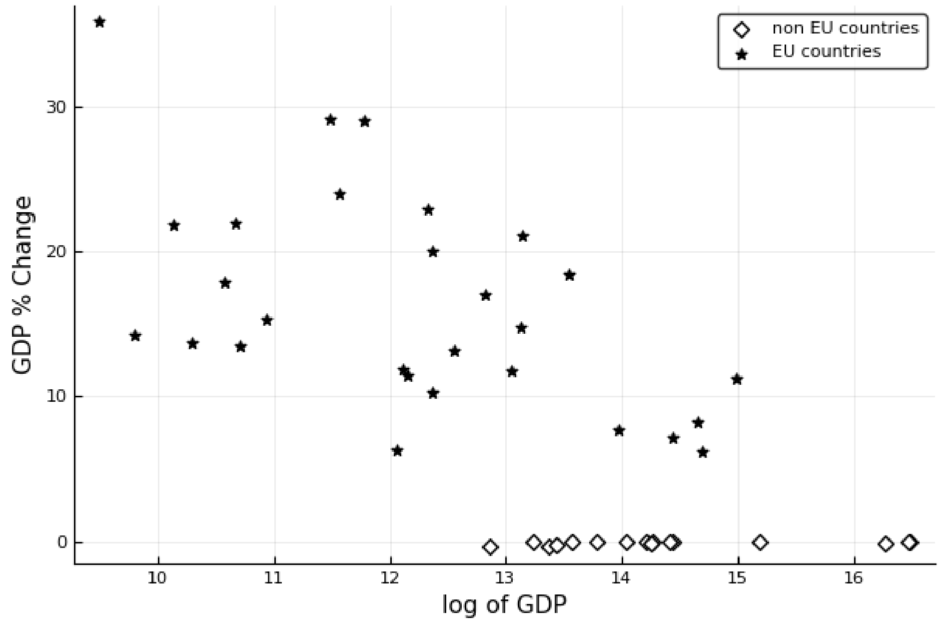


Figure 8: Welfare effects in all countries of decreasing log δ of EU-EU borders by -0.2700 for within-country level integration.

We next turn to do the opposite exercise. We decrease the log frictions between all pairs of EU countries by 0.2700, which is the difference in log frictions between Ireland and Scotland vis-a-vis the UK. We use this difference as it is the smallest of the differences over the three case studies that we looked at, and so is a conservative estimate of what we propose as the effect of integration within a country. That is, we decrease log frictions by 0.2700 whenever both parties are in the EU. As a consequence, world GDP would increase by a substantial 2.3%, but again this increase would be unevenly distributed. Countries outside of the EU see a slight decrease in their GDP of 0.1% as a consequence of suffering a real depreciation, while EU GDP increases by 10.9%. In Figure 8 we plot the effect for all countries along with the country size. The implied increase in welfare for small European countries is huge, with a smaller but still substantial impact on larger countries. As a benchmark, for the UK the increase is 6.2%.

The corollary of all this is that, even although the effects of the EU are substantial (because it decreases frictions between its members), there is a large difference between the frictions across the countries of the EU, and the friction within countries. Moreover, the welfare implications of those remaining frictions within countries seem to be almost an order of magnitude larger, and further

effect of the fall in income of EU countries, and we see that the overall impact of EU disintegration, -0.95%, is slightly less bad for the UK than a simple Brexit scenario, -0.97%.

integration between EU members could produce large welfare gains. This is entirely consistent with other results reported in the literature, such as Nitsch (2000). We do not speculate on the sources of this difference, other than to note that the existence of strong integration within a country the size of the USA suggests that size is not a factor here, rather there is either something special that countries achieve in terms of integration that the EU does not manage to replicate, or the EU is as yet too young, and these integration benefits have not yet had time to materialise.

5.3 Independence and EU membership

As an example of this almost order of magnitude difference between the welfare implications of within country frictions relative to the frictions between EU members, we revisit the case of Scottish independence. Following the "No" vote in the Scottish Independence Referendum in 2014, this issue may have been thought to have been resolved for a long period of time. However, with Scotland voting to "Remain" in the EU, while the UK-wide vote was to "Leave", in 2016's Brexit Referendum, Brexit has pushed the issue of Scottish independence back on to the political agenda. In this subsection we consider the "choice" now facing Scotland between "Brexit-ing" the EU along with the rest of the UK, or opting for independence and remaining within the EU. In Table 10 we report the implied changes in Scottish and rUK GDP for these two different policy experiments.

The first row conveys Brexit, while Scotland remains in the UK. The frictions for both Scotland and the rest of the UK with the rest of the EU increase by the *"marginal"* effect (increase log δ by 0.0736) while the frictions between Scotland and the rest of the UK remain as calibrated with the data[40]. The loss for the rest of the UK is 1.0% (about the same size as the loss for the whole of the UK that we saw before in Table 8, which makes sense given the small size of Scotland relative to the UK), while the loss for Scotland is slightly smaller, 0.8%, due to it being less open to foreign trade than the rest of the UK.

The second row of Table 10 is to (i) increase the frictions between the rest of the UK and the

[40] To do this we assume that Scottish external trade is split between the EU and the rest of the world in the same proportion as that of the UK as a whole. We only have export data split by destination for Scotland and in this data Scotland exports 43% of total international exports to the rest of the EU. This is very similar to the UK figure of 42%. In the exercises we do, it is both exports and imports that matter, and we have no data on the source of Scottish imports. Therefore we split Scottish external trade into rEU and RoW using the split that we see in the UK figures.

	$\delta_{Sct-rUK}$	$\delta_{rUK-rEU}$	$\delta_{Sct-rEU}$	Scotland	rUK
(0) Data	2.067	2.677	3.952	-	-
(1) Brexit, no independence	2.067	2.882	4.254	-0.8%	-1.0%
(2) Brexit, independence in EU	2.707	2.882	3.952	-8.4%	-1.7%
(3) Brexit, independence in EU	2.914	2.882	3.952	-9.6%	-1.8%
(4) Brexit, independence out of the EU	2.914	2.882	4.254	-10.5%	-1.8%

Table 10: Implied Welfare Changes for Scotland and the rest of the UK of (1) Brexit without Scottish independence, (2) Brexit & independence (Irish friction) while Scotland remains in the EU, (3) Brexit & independence (augmented Irish friction) while Scotland remains in the EU, and (4) Brexit & independence with Scotland out of the EU

EU in the same manner as before, (ii) to make the frictions between Scotland and the rest of the UK equal to the ones the UK has with Ireland like in section 4, and (iii) while leaving the frictions between Scotland and the EU intact. Thus, this scenario accounts for Scottish independence from the UK, and accession as an independent member state of the EU. This leads to a much larger loss in GDP for Scotland, of 8.4%[41] and a larger loss in GDP for rUK of 1.7% - which has suffered the double effect of Brexit (cost of around 1.0%) and increased trade frictions with Scotland (implied cost of around 0.7% of GDP).

Notice however that in this second row we have increased the frictions between Scotland and the rest of the UK "only" to the level that Ireland has with the UK now, while the UK is a member of the EU. Were we to increase this friction further (by the additional *"marginal"* effect of the EU) then we see in the third row that losses are now even larger.

Finally, and for completeness, in the 4th row we show the impact of Scottish independence and Brexit if Scotland does not remain within the EU. Clearly in this case the losses are again larger.

The loses for Scotland associated with Brexit are almost an order of magnitude smaller than the loses associated with severing the within-country levels of integration that Scotland has with the rest of the UK. The moral of this exercise is that even controlling for endogeneity effects in

[41]Notice again that this is a smaller loss than the 8.5% loss from the Scottish independence scenario considered in Table 3. This is because "after" suffering an 8.5% GDP loss on independence, Scotland then benefits marginally from trade diversion effects as rUK leaves the EU.

the formation of countries, country borders have very large implications for trade frictions, even within the European Union. Their effects are much larger than the, still significant, effects of the European Union. A corrollary of this is that there are large gains from trade still available in making the EU look like an integrated country in trade terms, though the political direction of travel seems to be very much against this at the moment.

6 Conclusion

In this paper we have presented evidence, consistent with the economic literature on the border effect, that regional borders are less frictional to trade than international borders (Table 1), even within the EU. Our econometric exercise can be used to construct policy experiments that provide an estimate of the welfare costs of changing regional borders to international borders (via political independence) or leaving the EU (i.e., Brexit) in standard gravity models of trade (Table 3).

However, we believe that this "average" border effect overestimates the impact of sharing a state: it is reasonable to expect that affinities that promote trade also promote selection into sharing a state. This means that it is likely that entities with otherwise low frictions "choose" to share a state and enjoy the integration benefit, whereas entities with high frictions "choose" to be independent countries. The average difference between borders within and across countries therefore overstates this integration benefit because of this selection bias. The same mechanism is likely to exist for selection into (or out of) organizations like the EU.

We propose a methodology to deal with this selection bias: identify *"marginal regions"* as those regions in our data with credible independence movements; and *"marginal countries"* with respect to country R as those countries with the lowest measured frictions with R; then the difference in frictions between a marginal region of country R and the marginal country with respect to country R, is a better estimate of the true economic integration benefit due to political integration than the average difference between regional and country borders. This is akin to performing a regression discontinuity analysis. By controlling for this selection bias, we reduce the estimated integration benefit in the case of Scotland, Catalonia and the Basque Country. Nevertheless, the estimates that we obtain are still very large indeed. Likewise by the same logic we estimate a cost of Brexit lower than that obtained by imputing the average difference in frictions between EU and non EU countries.

The first measurement of the border effect by McCallum (1995) showed it to be extremely large. By incorporating economic theory to the analysis, Anderson and van Wincoop (2003) reduced the measured effect. By controlling for selection bias we further reduce its importance, but a central claim of our paper is that it is still quantitatively significant. Our estimates are insensitive to parameters (trade elasticity) and insensitive to model specification (e.g. inclusion of intermediate goods) across a broad class of models from modern trade theory, and they tell the same story across the three examples that are in our data set: the gains from economic integration that come with political integration are worth between a third and a half of the total gains from trade, relative to autarky, enjoyed by these regions (Table 4). This large proportion of total gains from trade is a consequence of the extraordinary degree of integration that a region has with the rest of its country. Despite the EU being a trade promoting body, with quantitatively significant benefits, we do not observe the same degree of integration between countries, even within the European Union.

The differential trade promoting effects of sharing a country have consequences that are almost an order of magnitude larger than consequences of the differential effects of mutual EU membership. These consequences translate into large potential gains in welfare. These are the gains from economic integration that institutions like the European Union should strive to obtain.

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Appendices

A Data

A.1 Country Data

- WIOT2014_Nov16_ROW.xlsb downloaded from http://www.wiod.org/database/wiots16 - World Input-Output Tables, 2016 Release, WIOT 2014 link.
- This gives GDP, Gross Output and total (goods and services) bilateral trade flows for 2014, for 43 countries plus a rest of the world aggregate.
- Data on distance and common language etc, geo_cepii.xls and dist_cepii.xls, downloaded from GeoDist http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=6

A.2 US Data

- US State GDP for 2014, from Bureau of Economic Analysis https://www.bea.gov/itable/iTable.cfm?ReqID=70&step=1#reqid=70&step=10&isuri=1&7003=200&7035=-1&7004=naics&7005=1&7006=xx&7036=-1&7001=1200&7002=1&7090=70&7007=2014&7093=levels
- State Gross Output used in constructing the dataset is $US\,total\,Gross\,Output \times State\,GDP/\sum State\,GDPs$
- 2014 trade flows (goods only) between states and internationally from the Freight Analysis Framework http://faf.ornl.gov/fafweb/Extraction1.aspx
- State International Trade used in constructing the dataset is $US\,International\,Trade \times State\,International\,Trade/\sum States\,International\,Trade$
- State Internal Trade used in constructing the dataset is $US\,International\,Trade \times State\,Internal\,Trade/\sum States\,International\,Trade$
- Geographical data taken from http://bl.ocks.org/sjengle/5315515

A.3 Canadian Data

- 2013 Data obtained from Statistics Canada by downloading cansim-3860003-eng-5409715410633866536.csv from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3860003&tabMode=dataTable&p1=-1&p2=-1&srchLan=0&pattern=trade
- This gives GDPs and bilateral trade flows (either goods only, or goods and services) internally and internationally.
- Provincial Gross Output used in constructing the dataset is $Canadian\,total\,Gross\,Output \times Province\,GDP/\sum Province\,GDPs$
- Provincial International Trade used in constructing the dataset is $Canadian\,International\,Trade \times Province\,International\,Trade/\sum Provinces\,International\,Trade$
- Province Internal Trade used in constructing the dataset is $Canadian\,International\,Trade \times Province\,Internal\,Trade/\sum Provinces\,International\,Trade$
- Geographical data: "canada_provinces.csv" downloaded from https://www.webtrees.net/index.php/en/add-ons/category/5-gm-files

A.4 Scottish Data

- Scottish and UK GDP for 2014 obtained from "GERS" publication: 00523728.xlsx downloaded from http://www.gov.scot/Resource/0052/00523728.xlsx
- Scottish Gross Output used in constructing the dataset is
  $UK\,total\,Gross\,Output \times GERS\,Scottish\,GDP/GERS\,UK\,GDP$
- Goods and services trade with rest of UK and with rest of the world from Scottish Government's Input-Output (IO) tables for 2014. These tables also give a measure of Scottish Gross Output. 00522788.xlsx downloaded from http://www.gov.scot/Resource/0052/00522788.xlsx
- Scottish Trade with i ($i = rUK$ or RoW) used in constructing the dataset is
  $Scottish\,Gross\,Output \times Scottish\,IO\,Trade\,with\,i/Scottish\,IO\,Gross\,Output$
- rUK trade with RoW used in constructing the dataset is $UK\,Trade\,with\,RoW - Scottish\,Trade\,with\,RoW$
- Scottish exports to the rest of the world, as calculated above, are split by destination using Export Statistics Scotland 2015 data for 2014 for use in Herfindahl calc: 00526194.xlsx dowloaded from http://www.gov.scot/Topics/Statistics/Browse/Economy/Exports/ESSPublication/ESSExcel
- Geographical data: coordinates for Edinburgh obtained from google search.

A.5 Spanish Data

- Autonomous Community GDPs in 2006 from Eurostat ("Regional gross domestic product by NUTS 2 regions - million EUR, Code: tgs00003")
- A.C. Gross Output used in constructing the dataset is
  $Spanish\,total\,Gross\,Output \times A.C.\,GDP/\sum A.C.\,GDPs$
- Goods only trade data, as at 2006, for all Spanish Autonomous Communities in terms of imports and exports to the rest of Spain and internationally, from C-Intereg 2008: Table 6 on p28 of http://www.c-intereg.es/El_Comercio_hnterregional_en_Espa%C3%B1a_1995-2006_29_10_08.pdf
- Provincial International Trade used in constructing the dataset is
  $Spanish\,International\,Trade \times A.C.\,International\,Trade/\sum A.C.\,International\,Trade$
- A.C. Internal Trade used in constructing the dataset is
  $Spanish\,International\,Trade \times A.C.\,Internal\,Trade/\sum A.C.\,International\,Trade$
- Geographical data: Regional capital coordinates for Spanish autonomous communities obtained from individual google searches.

A.6 Catalonia

- Goods and services trade (G&S) data with rest of Spain and with rest of the world as at 2005 is available from Comptes econòmics simplificats de l'economia catalana 2005
- Catalan Gross Output and International trade are as calculated using the Spanish A.C. (AC) data above
- Catalan Internal trade used here is
  $Catalan\,(AC)\,International\,Trade \times Catalan\,(G\&S)\,Internal\,Trade/Catalan\,(G\&S)\,Internal\,Trade$
- Catalan exports to the rest of the world, as calculated above, are split by destination using the split for Spain as a whole, for use in Herfindahl calc.

A.7 Basque Country

- Goods and services trade (G&S) data with rest of Spain and with rest of the world as at 2006 is available from http://en.eustat.es/elementos/ele0010000/ti_Gross_Domestic_Product_of_the_Basque_Country_by_components_Supply_and_demand_Current_prices_thousands_of_euros_2005-2012a/tbl0010072_h.html#axzz2vHsbZzjnexpressed
- Basque Gross Output and International trade are as calculated using the Spanish A.C. (AC) data above
- Basque Internal trade used here is $Basque\,(AC)\,International\,Trade \times Basque\,(G\&S)\,Internal\,Trade / Basque\,(G\&S)\,Internal\,Trade$
- Basque exports to the rest of the world, as calculated above, are split by destination using the split for Spain as a whole, for use in Herfindahl calc.

B Negative Relationship Between Size and Measured Frictions

It is obvious that trade frictions should depend positively on physical distance, and negatively on whether the entities have a common language. But it is much less obvious why there should be a significant dependence on the size of the entities. In this section we will show that aggregation can explain this negative dependence. To this end, we conduct the following exercise. We assume the existence economies, and fix their trade patterns. We then view these economies at different scales of aggregation (for small or large "countries") and examine how the measured HRI changes with scale.

Suppose a large number, N, of very small, identical economies. Within these very small economies, there are no trade frictions. Each of these economies has gross output, Y, and home trade share, λ, and every bilateral pair in this world is associated with the same trade friction, $\bar{\delta} > 1$ and consequently, trade flow X. We can then look at aggregations of these small units. Suppose the underying small economies are indexed $1, ..., N$ but that we can only observe aggregations ("countries") $K = \{1, ..., k\}$ and $M = \{k+1, ..., k+m < N\}$. Then we want to examine the relationship between the size of these aggregations/countries, k & m, and the measured HRI between them. We are imposing the same frictions between any two fundamental units and no extra friction for trade across the border of the *data gathering units* , K & M. Therefore, if the measured HRI reflected only true trade frictions then it should be independent of k & m. On the other hand, if there is a relationship, does it explain the slope in Figure 2, or does this figure show some true relationship between size and HRI?

We can solve for the bilateral trade flow X between each unit, in terms of the home share λ, the true bilateral trade friction $\bar{\delta}$, the gross output Y, and the trade elasticity ϵ, by manipulating Equation (2):

$$\bar{\delta} = \left(\frac{X^2}{(Y-(N-1)X)^2} \right)^{\frac{1}{2\epsilon}} \;\&\; \lambda = \frac{Y-(N-1)X}{Y} \Rightarrow X = \lambda Y \bar{\delta}^{\epsilon}$$

Now consider the case where we cannot observe these small identical units, but instead the observed actual countries are aggregrations $K = \{1, ..., k\}$ and $M = \{k+1, ..., k+m\}$ of non-overlapping underlying "countries". In this case:

$$\begin{aligned} Y_K &= kY \\ Y_M &= mY \\ X_{KK} &= k\lambda Y + k(k-1)X \\ X_{MM} &= m\lambda Y + m(m-1)X \\ X_{KM} &= kmX = X_{MK} \end{aligned}$$

If we now measure the HRI associated with this KM bilateral relationship, we obtain

$$\ln \delta_{KM} = \frac{1}{\epsilon} \ln \left(\frac{X_{KM}}{X_{KK}^{1/2} X_{MM}^{1/2}} \right) = \frac{1}{\epsilon} \ln \left(\frac{k^{1/2} m^{1/2} \bar{\delta}^{\epsilon}}{(1+(k-1)\bar{\delta}^{\epsilon})^{1/2}(1+(m-1)\bar{\delta}^{\epsilon})^{1/2}} \right)$$

Differentiating $\ln \delta_{KM}$ by $\ln Y_K$ and evaluating this at $k = 1$ gives

$$\begin{aligned} \frac{\partial \ln \delta_{KM}}{\partial \ln Y_K} &= \frac{\partial \ln \delta_{KM}}{\partial \ln k} = \frac{1}{2\epsilon} \left(1 - \frac{\bar{\delta}^{\epsilon} k}{1+(k-1)\bar{\delta}^{\epsilon}} \right) < 0 \\ \text{i.e. } \frac{\partial \ln \delta_{KM}}{\partial \ln Y_K}(k=1) &= \frac{\partial \ln \delta_{KM}}{\partial \ln Y_M}(m=1) = \frac{1-\bar{\delta}^{\epsilon}}{2\epsilon} < 0 \end{aligned}$$

Therefore, purely from aggregation effects rather than any real frictions, we would expect to observe a negative relationship between the log of the HRI and log incomes with a slope in the range $\frac{1}{2\epsilon} < 0$ (for high values of $\bar{\delta}$) to 0 (for a value of $\bar{\delta} \approx 1$). This range, given the value $\epsilon = -3.5$ used to generate Figure 2, is $(-0.142, 0)$. The empirically observed slope shown in Figure 2 is -0.103. There is therefore no evidence of any true relationship between size and HRI, with the negative slope being within the expected range.

The intuition for this negative dependence of HRI upon size is that the HRI measure is a relative measure: it measures the friction for trade with the other party relative to trade with yourself. Larger countries have larger internal trade frictions and so a lower relative increase in frictions with external entities. Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016) provide a model for internal frictions which deals with this effect. Doing this requires additional data, and in a simple and parsimonious specification like that used in this paper, we cannot separately identify the productivity of the economies from their internal trade frictions. We can however control for this phenomenon by looking at the residual over and above what we expect given size effects.

We expect frictions to depend positively on physical distance, and negatively on a common official language. We have now shown[42] that we also expect frictions to depend negatively upon the incomes of the trading partners due to aggregation. We now look at the residual frictions controlling (via the regression coefficents from Table 1) for these three factors.

C Armington Model with Intermediate Goods

Extending Anderson and van Wincoop (2003) (which in turn follows from Anderson (1979)) to include intermediate goods.

- Let $h, j \in \{1, ..., N\}$ index countries in the multilateral trade database
- Let $i_{hj} + c_{hj} \equiv$ the real quantity of goods used in j that were produced in h. These goods as far as j is concerned have a unit cost of $p_h \delta_{hj}$. The real quantity of goods supplied by h to j however is $\delta_{hj} (i_{hj} + c_{hj})$ at unit cost p_h. The expenditure from j on h goods is therefore $p_h \delta_{hj} (i_{hj} + c_{hj})$ no matter where viewed from.

[42] Coughlin and Novy (2016) also make this point.

- Production is Cobb-Douglas with share β on intermediate goods (CES aggregate of all produced goods with elasticity of substitution σ), and share $1-\beta$ on the "real endowment of inputs", S_j, in economy j (endowment-ish economy i.e. S_j (which is like the supply of effective labour) does not change when implementing policy experiments). Output goods are priced at p_j

  i.e. Nominal Gross Output "production function"

$$X_j = p_j S_j^{1-\beta} \left(\left[\sum_h i_{hj}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \right)^{\beta} = p_j S_j^{1-\beta} I_j^{\beta}$$

  and Nominal Gross Output by destination of goods produced

$$X_j = \sum_h p_j \delta_{jh} \left(i_{jh} + c_{jh} \right) \equiv \sum_h X_{jh}$$

  But balanced trade also implies

$$X_j = \sum_h X_{hj} = \sum_h p_h \delta_{hj} \left(i_{hj} + c_{hj} \right)$$

  where the c's are disaggregated consumption goods and i's are disaggregated intermediate goods

- Nominal GDP (Expenditure)

$$Y_j = P_j C_j = \sum_h p_h \delta_{hj} c_{hj}$$

  Nominal GDP (Income)

$$Y_j = X_j - \sum_h p_h \delta_{hj} i_{hj}$$

- Utility U_j is equal to real consumption C_j which is CES aggregation (elasticity of substitution σ) of disaggregated goods

$$C_j = \left[\sum_h c_{hj}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

- Utility maximisation taking prices and income as given implies

$$\delta_{hj} p_h = P_j \left(\frac{c_{hj}}{C_j} \right)^{-\frac{1}{\sigma}}$$

  where

$$P_j = \left[\sum_h \left(\delta_{hj} p_h \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

- Economy j spends $P_j' I_j$ on intermediate goods i.e.

$$P_j' I_j = \sum_h p_h \delta_{hj} i_{hj}$$

  Given this level of expenditure, economy j will want to maximise the quantity of the aggregate intermediate good that it purchases. This implies:

$$P'_j = P_j$$
$$\delta_{hj} p_h = P_j \left(\frac{i_{hj}}{I_j}\right)^{-\frac{1}{\sigma}}$$

- The income version of GDP expression implies that the "cost" of the endowment is GDP i.e.

$$X_j = Y_j + P_j I_j$$

If using a unit of the endowment has a price W_j then

$$Y_j = W_j S_j$$

Cost minimisation in the production of X_j, faced with prices W_j for the use of the endowment, and P_j for the use of intermediates, implies

$$Y_j = P_j C_j = \frac{1-\beta}{\beta} P_j I_j = (1-\beta) X_j$$

which means that

$$\frac{i_{hj}}{c_{hj}} = \frac{I_j}{C_j} = \frac{X_j - Y_j}{Y_j} = \frac{\beta}{1-\beta}$$

- Nominal expenditure of economy j in economy h allows us to derive the gravity equation of the model

$$X_{hj} = p_h \delta_{hj} \left(i_{hj} + c_{hj}\right) = \ldots$$
$$= \left(\frac{1}{1-\beta}\right) p_h^{1-\sigma} \delta_{hj}^{1-\sigma} P_j^{\sigma-1} Y_j$$

$$X_h = \sum_k X_{hk} = p_h^{1-\sigma} \left(\frac{1}{1-\beta}\right) \sum_k \delta_{hk}^{1-\sigma} P_k^{\sigma-1} Y_k$$
$$\text{i.e. } p_h^{1-\sigma} = \frac{Y_h}{\sum_k \delta_{hk}^{1-\sigma} P_k^{\sigma-1} Y_k}$$

$$X_{hj} = \frac{1}{1-\beta} \frac{Y_h Y_j}{P_h \sum_k \left(\frac{P_h}{P_k}\right)^{-\sigma} \delta_{hk}^{1-\sigma} \left(\frac{Y_k}{P_k}\right)} \left(\frac{P_h}{P_j} \delta_{hj}\right)^{1-\sigma}$$
$$= \frac{1}{1-\beta} \frac{Y_h Y_j}{D_h} \left(\frac{P_h}{P_j} \delta_{hj}\right)^{1-\sigma}$$

where

$$D_h = P_h \sum_k \left(\frac{P_h}{P_k}\right)^{-\sigma} \delta_{hk}^{1-\sigma} \left(\frac{Y_k}{P_k}\right)$$

- Also have, in this general case,

$$X_{hj} X_{jh} = \left(\frac{1}{1-\beta}\right)^2 \frac{Y_h^2 Y_j^2}{D_h D_j} \left(\delta_{hj} \delta_{jh}\right)^{1-\sigma}$$

- Make parameter and data restrictions to simplify the model so that, as we show, it becomes very easy to calibrate:

$$\delta_{jj} = 1$$
$$\delta_{hj} > 1, \; h \neq j$$

Now have

$$X_{hh} = \frac{1}{1-\beta}\frac{Y_h^2}{D_h}$$
$$D_h = \frac{1}{1-\beta}\frac{Y_h^2}{X_{hh}}$$

- Also impose

$$\delta_{hj} = \delta_{jh}$$

Then

$$X_{hj}X_{jh} = \left(\frac{1}{1-\beta}\right)^2 \frac{Y_h^2 Y_j^2}{D_h D_j}\delta_{hj}^{2(1-\sigma)} = X_{hh}X_{jj}\delta_{hj}^{2(1-\sigma)}$$
$$\text{i.e. } \delta_{hj} = \left(\frac{X_{hj}X_{jh}}{X_{hh}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}}$$

Note that a corrolary of this is, since δ_{hj} is determined purely with reference to data on h, j and their interaction (as well as σ), the aggregation of the rest of the world other than h and j makes no difference to the calibrated value of δ_{hj}. The rest of the world can be expressed as a single aggregate RoW entity, or disaggregated into its constituent countries, without affecting the value of δ_{hj}.

- Allen, Arkolakis, and Takahashi (2014) show that

$$X_j = \sum_h X_{hj} = \sum_h X_{jh}$$

and

$$\delta_{hj} = \delta_{jh}$$

imply

$$X_{hj} = X_{jh}$$

i.e. bilaterally balanced trade

In Appendix D, we demonstrate that this is true for a three country version of the model

- Then

$$X_{hj} = \frac{1}{1-\beta}\frac{Y_h Y_j}{D_h}\left(\frac{P_h}{P_j}\delta_{hj}\right)^{1-\sigma} = \frac{1}{1-\beta}\frac{Y_h Y_j}{D_j}\left(\frac{P_j}{P_h}\delta_{hj}\right)^{1-\sigma} = X_{jh}$$

i.e.

$$\left(\frac{P_h}{P_j}\right)^{1-\sigma} = \left(\frac{D_h}{D_j}\right)^{\frac{1}{2}}$$

so that

$$X_{hj} = \frac{1}{1-\beta}\frac{Y_h Y_j}{(D_h D_j)^{\frac{1}{2}}}\delta_{hj}^{1-\sigma}$$

- In logs
$$\ln X_{hj} = -\ln(1-\beta) + \ln Y_h + \ln Y_j - \frac{1}{2}\ln D_h - \frac{1}{2}\ln D_j + (1-\sigma)\ln\delta_{hj}$$
i.e. the Trade Elasticity, $\varepsilon = 1-\sigma$

- The econometric estimation of section 2 is
$$\frac{1}{1-\sigma}\left[\ln X_{hj} + \ln(1-\beta) - \ln Y_h + \ln Y_j + \frac{1}{2}\ln D_h \frac{1}{2}\ln D_j\right] = \ln\delta_{hj} = \alpha_1 E_1 + ... + \alpha_m E_m$$
where $E_l, l \in \{1, ..., m\}$ are m explanatory variables, including existence of a border, for bilateral trade frictions. Note that the coefficients on the explanations for trade frictions depend upon elasticity, σ.

D Bilaterally Balanced Trade

Theorem: In a 3 country model with symmetric trade frictions, trade is bilaterally balanced

Proof:

- Always have
$$X_h = \sum_{j=1}^{3} X_{hj} = \sum_{j=1}^{3} X_{jh}$$
i.e. 3 equations in 6 unknowns. Suppose X_{12}, X_{13}, X_{23} are "known", then we have 3 equations
$$\begin{aligned} X_{12} + X_{13} &= X_{21} + X_{31} \\ X_{21} + X_{23} &= X_{12} + X_{32} \\ X_{31} + X_{32} &= X_{13} + X_{23} \end{aligned}$$
in 3 unknowns, i.e.
$$\begin{aligned} X_{21} + X_{31} &= X_{12} + X_{13} \\ X_{21} - X_{32} &= X_{12} - X_{23} \\ X_{31} + X_{32} &= X_{13} + X_{23} \end{aligned}$$
or
$$\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} X_{21} \\ X_{31} \\ X_{32} \end{bmatrix} = \begin{bmatrix} X_{12} + X_{13} \\ X_{12} - X_{23} \\ X_{13} + X_{23} \end{bmatrix}$$
However, this matrix is singular so cannot be inverted to evaluate X_{21}, X_{31}, X_{32} in terms of X_{12}, X_{13}, X_{23}. This can be seen by noting that adding equations 2 and 3 together gives equation 1, so they are not linearly independent.

- Need to exploit more information...

- Note however that this system does say that:

$$X_{21} - X_{12} = X_{13} - X_{31}$$
$$X_{21} - X_{12} = X_{32} - X_{23}$$
$$X_{31} - X_{13} = X_{23} - X_{32}$$

i.e. if trade bilaterally balanced anywhere, then it's bilaterally balanced everywhere.

- Normalise price index in economy 1 (this is what we do in the calibration)

$$P_1 = 1$$

- Then define

$$\delta_j \equiv \delta_{1j} = \left((1-\beta)\,\frac{X_{1j}D_1}{Y_1Y_j}\right)^{\frac{1}{1-\sigma}}\,\frac{P_j}{P_1} = \left((1-\beta)\,\frac{X_{1j}D_1}{Y_1Y_j}\right)^{\frac{1}{1-\sigma}}\,P_j$$

So that

$$\begin{aligned}\delta_{hj} &= \left((1-\beta)\,\frac{X_{hj}D_h}{Y_hY_j}\right)^{\frac{1}{1-\sigma}}\,\frac{P_j}{P_h} = \ldots \\ &= \frac{\delta_j}{\delta_h}\left(\frac{X_{1h}X_{hj}}{X_{1j}X_{hh}}\right)^{\frac{1}{1-\sigma}}\end{aligned}$$

- Impose symmetric frictions, then

$$\begin{aligned}\delta_{1j} &= \frac{\delta_j}{1}\left(\frac{X_{11}X_{1j}}{X_{1j}X_{11}}\right)^{\frac{1}{1-\sigma}} = \frac{1}{\delta_j}\left(\frac{X_{1j}X_{j1}}{X_{11}X_{jj}}\right)^{\frac{1}{1-\sigma}} = \delta_{j1} \\ \delta_j &= \left(\frac{X_{1j}X_{j1}}{X_{11}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}}\end{aligned}$$

so

$$\begin{aligned}\delta_{hj} &= \left(\frac{X_{1h}X_{j1}}{X_{h1}X_{1j}}\,\frac{X_{hj}^2}{X_{hh}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}} \\ \delta_{jh} &= \left(\frac{X_{1j}X_{h1}}{X_{j1}X_{1h}}\,\frac{X_{jh}^2}{X_{jj}X_{hh}}\right)^{\frac{1}{2(1-\sigma)}}\end{aligned}$$

and

$$\delta_{hj} = \left(\frac{X_{1h}X_{j1}}{X_{h1}X_{1j}}\,\frac{X_{hj}^2}{X_{hh}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}} = \left(\frac{X_{1j}X_{h1}}{X_{j1}X_{1h}}\,\frac{X_{jh}^2}{X_{jj}X_{hh}}\right)^{\frac{1}{2(1-\sigma)}} = \delta_{jh}$$

i.e.

$$\frac{X_{jh}}{X_{hj}} = \frac{X_{1h}X_{j1}}{X_{h1}X_{1j}}$$

- This means that e.g.

$$\frac{X_{32}}{X_{23}} = \frac{X_{12}X_{31}}{X_{21}X_{13}}$$

- Therefore

$$X_{21} + X_{31} = X_{12} + X_{13} = A$$
$$X_{21} - X_{32} = X_{12} - X_{23} = B$$
$$\frac{X_{32}X_{21}}{X_{31}} = \frac{X_{12}X_{23}}{X_{13}} = C$$

i.e.

$$X_{32} = C\frac{X_{31}}{X_{21}}$$

$$X_{31} = \frac{1}{C}X_{21}\left(X_{21} - B\right)$$

$$\frac{1}{C}X_{21}^2 + \left(1 - \frac{B}{C}\right)X_{21} - A = 0$$

and eventually

$$\begin{aligned}
X_{21} &= \frac{-\left(1-\frac{B}{C}\right) + \sqrt{\left(1-\frac{B}{C}\right)^2 + 4\frac{1}{C}A}}{2\frac{1}{C}} \\
&= \frac{1}{2}\left(B - C + \sqrt{C^2 + B^2 - 2BC + 4AC}\right) \\
&= \frac{1}{2}\left(X_{12} - X_{23} - \left(\frac{X_{12}X_{23}}{X_{13}}\right)\right) + \frac{1}{2}\times \\
&\quad \sqrt{\left(\frac{X_{12}X_{23}}{X_{13}}\right)^2 + \left(X_{12} - X_{23}\right)^2 - 2\left(X_{12} - X_{23}\right)\left(\frac{X_{12}X_{23}}{X_{13}}\right) + 4\left(X_{12} + X_{13}\right)\left(\frac{X_{12}X_{23}}{X_{13}}\right)} \\
&= \frac{1}{2}\left(X_{12} - X_{23} - \left(\frac{X_{12}X_{23}}{X_{13}}\right)\right) + \\
&\quad \frac{1}{2}\frac{1}{X_{13}}\sqrt{X_{12}^2X_{13}^2 + 2X_{12}X_{13}^2X_{23} + 2X_{12}^2X_{13}X_{23} + X_{13}^2X_{23}^2 + 2X_{12}X_{13}X_{23}^2 + X_{12}^2X_{23}^2} \\
&= \frac{1}{2}\left(X_{12} - X_{23} - \left(\frac{X_{12}X_{23}}{X_{13}}\right) + \frac{1}{X_{13}}\sqrt{\left(X_{12}X_{13} + X_{13}X_{23} + X_{12}X_{23}\right)^2}\right) \\
&= X_{12}
\end{aligned}$$

as req.

- Since we have $X_{21} = X_{12}$, we have already shown that trade is bilaterally balanced everywhere i.e. $X_{31} = X_{13}$ and $X_{32} = X_{23}$.

E Calibration

- Price index in country 1, P_1, is assumed to be normalised to 1.
- Have

$$D_h = \frac{Y_h^2}{\left(1-\beta\right)X_{hh}}$$

- And

$$\delta_{hj} = \left(\frac{X_{hj}X_{jh}}{X_{hh}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}} = \left(\frac{X_{hj}^2}{X_{hh}X_{jj}}\right)^{\frac{1}{2(1-\sigma)}}$$

and

$$P_j^{1-\sigma} = P_k^{1-\sigma}\left(\frac{D_j}{D_k}\right)^{\frac{1}{2}} = \sum_h \left(\delta_{hj} p_h\right)^{1-\sigma}$$

Since data, $\{Y_h, X_{hj}\}$, gives D_h & hence δ_{hj}, and given the normalisation $P_1 = 1$, this is a system of N linear equations in N unknowns, $\left\{p_1^{1-\sigma}, p_2^{1-\sigma}, ..., p_N^{1-\sigma}\right\}$

$$P_1^{1-\sigma}\left(\frac{D_j}{D_1}\right)^{\frac{1}{2}} = \left(\frac{D_j}{D_1}\right)^{\frac{1}{2}} = \sum_h \left(\delta_{h1} p_h\right)^{1-\sigma}$$

- Example with 3 countries:
  - data & parameters

$$\begin{aligned}
&Y_1, Y_2, Y_3 \\
X_{12} &= X_{21}, X_{13} = X_{31}, X_{23} = X_{32} \\
X_{11} &= \frac{Y_1}{1-\beta} - X_{12} - X_{13} \\
X_{22} &= \frac{Y_2}{1-\beta} - X_{12} - X_{23} \\
X_{33} &= \frac{Y_3}{1-\beta} - X_{13} - X_{23} \\
\sigma, \delta_{11} &= \delta_{22} = \delta_{33} = 1
\end{aligned}$$

  - Equations:

$$\begin{aligned}
D_1 &= \frac{Y_1^2}{(1-\beta) X_{11}} \\
D_2 &= \frac{Y_2^2}{(1-\beta) X_{22}} \\
D_3 &= \frac{Y_3^2}{(1-\beta) X_{33}}
\end{aligned}$$

$$\begin{aligned}
\delta_{12} &= \left(\frac{X_{12}^2}{X_{11} X_{22}}\right)^{\frac{1}{2(1-\sigma)}} \\
\delta_{13} &= \left(\frac{X_{13}^2}{X_{11} X_{33}}\right)^{\frac{1}{2(1-\sigma)}} \\
\delta_{23} &= \left(\frac{X_{23}^2}{X_{22} X_{33}}\right)^{\frac{1}{2(1-\sigma)}} \\
P_1 &= 1 \text{ (normalisation)}
\end{aligned}$$

$$1 = (\delta_{11}p_1)^{1-\sigma} + (\delta_{21}p_2)^{1-\sigma} + (\delta_{31}p_3)^{1-\sigma}$$
$$\left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} = (\delta_{12}p_1)^{1-\sigma} + (\delta_{22}p_2)^{1-\sigma} + (\delta_{32}p_3)^{1-\sigma}$$
$$\left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} = (\delta_{13}p_1)^{1-\sigma} + (\delta_{23}p_2)^{1-\sigma} + (\delta_{33}p_3)^{1-\sigma}$$

$$\begin{bmatrix} p_1^{1-\sigma} \\ p_2^{1-\sigma} \\ p_3^{1-\sigma} \end{bmatrix} = \begin{bmatrix} 1 & \delta_{12}^{1-\sigma} & \delta_{13}^{1-\sigma} \\ \delta_{12}^{1-\sigma} & 1 & \delta_{23}^{1-\sigma} \\ \delta_{13}^{1-\sigma} & \delta_{23}^{1-\sigma} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \\ \left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} \end{bmatrix}$$

$$P_2^{1-\sigma} = P_1^{1-\sigma}\left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} = \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}}$$
$$P_3^{1-\sigma} = P_1^{1-\sigma}\left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} = \left(\frac{D_3}{D_1}\right)^{\frac{1}{2}}$$

F Policy experiment

- data and parameters

$$\begin{aligned} &\sigma \\ &S_1, S_2, S_3 \text{ (exogenous supply)} \\ &\delta_{11} = \delta_{22} = \delta_{33} = 1 \\ &\delta_{12} = \delta_{21}, \delta_{13} = \delta_{31}, \delta_{23} = \delta_{32} \text{ (pol exp)} \\ &P_1 = 1 \text{ (normalisation)} \end{aligned}$$

- 8 Unknowns

$$\{p_1, p_2, p_3, P_2, P_3, D_1, D_2, D_3\}$$

- 8 Equations

$$\begin{bmatrix} p_1^{1-\sigma} \\ p_2^{1-\sigma} \\ p_3^{1-\sigma} \end{bmatrix} = \begin{bmatrix} 1 & \delta_{12}^{1-\sigma} & \delta_{13}^{1-\sigma} \\ \delta_{12}^{1-\sigma} & 1 & \delta_{23}^{1-\sigma} \\ \delta_{13}^{1-\sigma} & \delta_{23}^{1-\sigma} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \\ \left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} \end{bmatrix}$$

$$P_2^{1-\sigma} = \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}}$$
$$P_3^{1-\sigma} = \left(\frac{D_3}{D_1}\right)^{\frac{1}{2}}$$

where D's must satisfy:

$$D_1 = P_1 \left[\frac{Y_1}{P_1} + \left(\frac{P_1}{P_2}\right)^{-\sigma} \delta_{12}^{1-\sigma} \frac{Y_2}{P_2} + \left(\frac{P_1}{P_3}\right)^{-\sigma} \delta_{13}^{1-\sigma} \frac{Y_3}{P_3} \right]$$
$$D_2 = P_2 \left[\left(\frac{P_2}{P_1}\right)^{-\sigma} \delta_{21}^{1-\sigma} \frac{Y_1}{P_1} + \frac{Y_2}{P_2} + \left(\frac{P_2}{P_3}\right)^{-\sigma} \delta_{23}^{1-\sigma} \frac{Y_3}{P_3} \right]$$
$$D_3 = P_3 \left[\left(\frac{P_3}{P_1}\right)^{-\sigma} \delta_{31}^{1-\sigma} \frac{Y_1}{P_1} + \left(\frac{P_3}{P_2}\right)^{-\sigma} \delta_{32}^{1-\sigma} \frac{Y_2}{P_2} + \frac{Y_3}{P_3} \right]$$

with

$$Y_j = S_j (1-\beta) \left(\frac{\beta}{P_j} p_j^{\frac{1}{\beta}} \right)^{\frac{\beta}{1-\beta}}$$

$$W_j = (1-\beta) \left(\frac{\beta}{P_j} p_j^{\frac{1}{\beta}} \right)^{\frac{\beta}{1-\beta}}$$

- Welfare impact:

$$\left(\frac{Y_h'/P_h'}{Y_h/P_h} \right) - 1$$

where dashed quantities are in policy experiment and undashed quantities are in the calibration.

- Counterfactual trade flows given by

$$X_{jj} = \frac{Y_j^2}{(1-\beta) D_j}$$
$$X_{hj} = \frac{1}{1-\beta} Y_h Y_j D_h^{-\frac{1}{2}} D_j^{-\frac{1}{2}} \delta_{hj}^{1-\sigma}$$

G Welfare formula

- Data
  - Home share, λ

$$\lambda = \frac{X_{11}}{X_1} = \frac{X_1 - X_{12}}{X_1}$$

  - Normalise GDP i.e.

$$Y_1 = 1 = (1-\beta) X_1$$

  - i.e.

$$X_1 = \frac{1}{1-\beta}$$
$$X_{11} = \frac{\lambda}{1-\beta}$$
$$X_{12} = \frac{1-\lambda}{1-\beta}$$

- Have, from gravity equations

$$X_{11} = \frac{1}{1-\beta} Y_1 Y_1 D_1^{-1}$$
$$\text{i.e. } D_1 = \frac{1}{1-\beta}\frac{1}{X_{11}} = \frac{1}{\lambda}$$

$$X_{12} = \frac{1}{1-\beta} Y_1 Y_2 D_1^{-\frac{1}{2}} D_2^{-\frac{1}{2}} \delta^{1-\sigma}$$
$$= \frac{\lambda^{\frac{1}{2}}}{1-\beta}\frac{Y_2}{D_2^{\frac{1}{2}}}\delta^{1-\sigma} = \frac{1-\lambda}{1-\beta}$$

$$X_{22} = \frac{1}{1-\beta} Y_2 Y_2 D_2^{-1}$$
$$\text{i.e. } \frac{Y_2}{D_2^{\frac{1}{2}}} = X_{22}^{\frac{1}{2}} (1-\beta)^{\frac{1}{2}}$$

so

$$\delta = \left(\frac{1-\lambda}{\lambda^{\frac{1}{2}} X_{22}^{\frac{1}{2}} (1-\beta)^{\frac{1}{2}}} \right)^{\frac{1}{1-\sigma}}$$

which is the same as

$$\delta = \left(\frac{X_{12}^2}{X_{11} X_{22}} \right)^{\frac{1}{2(1-\sigma)}}$$
$$\text{i.e. } X_{22} = \frac{X_{12}^2}{X_{11}} \delta^{-2(1-\sigma)}$$
$$= \frac{(1-\lambda)^2}{\lambda (1-\beta) \delta^{2(1-\sigma)}}$$

also have

$$D_2 = \frac{Y_2^2}{X_{22}(1-\beta)}$$

- Adding up in 2nd economy

$$\frac{Y_2}{1-\beta} = X_2 = X_{22} + X_{12}$$

$$D_2 = \frac{Y_2^2}{X_{22}(1-\beta)} = (1-\beta)\frac{(X_{22}+X_{12})^2}{X_{22}}$$
$$= (1-\beta)\frac{(X_{22}+X_{12})^2}{X_{22}}$$
$$= (1-\beta)\frac{\left(\frac{(1-\lambda)^2}{\lambda(1-\beta)\delta^{2(1-\sigma)}} + \frac{1-\lambda}{1-\beta}\right)^2}{\frac{(1-\lambda)^2}{\lambda(1-\beta)\delta^{2(1-\sigma)}}}$$
$$= \frac{\left(1-\lambda+\lambda\delta^{2(1-\sigma)}\right)^2}{\lambda\delta^{2(1-\sigma)}}$$

- Then 5 Equations

$$1 = p_1^{1-\sigma} + \delta^{1-\sigma} p_2^{1-\sigma}$$

$$\left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} = \delta^{1-\sigma} p_1^{1-\sigma} + p_2^{1-\sigma}$$

$$\begin{bmatrix} 1 \\ \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \end{bmatrix} = \begin{bmatrix} 1 & \delta^{1-\sigma} \\ \delta^{1-\sigma} & 1 \end{bmatrix} \begin{bmatrix} p_1^{1-\sigma} \\ p_2^{1-\sigma} \end{bmatrix}$$

$$\begin{bmatrix} p_1^{1-\sigma} \\ p_2^{1-\sigma} \end{bmatrix} = \begin{bmatrix} 1 & \delta^{1-\sigma} \\ \delta^{1-\sigma} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \end{bmatrix}$$

$$P_2^{1-\sigma} = \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}}$$

where D's must satisfy:

$$D_1 = P_1 \left[\frac{Y_1}{P_1} + \left(\frac{P_1}{P_2}\right)^{-\sigma} \delta^{1-\sigma} \frac{Y_2}{P_2}\right]$$

$$D_2 = P_2 \left[\left(\frac{P_2}{P_1}\right)^{-\sigma} \delta^{1-\sigma} \frac{Y_1}{P_1} + \frac{Y_2}{P_2}\right]$$

with

$$Y_j = S_j (1-\beta) \left(\frac{\beta}{P_j} p_j^{\frac{1}{\beta}}\right)^{\frac{\beta}{1-\beta}}$$

$$W_j = (1-\beta) \left(\frac{\beta}{P_j} p_j^{\frac{1}{\beta}}\right)^{\frac{\beta}{1-\beta}}$$

- i.e.

$$\begin{aligned} \begin{bmatrix} p_1^{1-\sigma} \\ p_2^{1-\sigma} \end{bmatrix} &= \begin{bmatrix} 1 & \delta^{1-\sigma} \\ \delta^{1-\sigma} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \end{bmatrix} \\ &= \frac{1}{1-\delta^{2(1-\sigma)}} \begin{bmatrix} 1 & -\delta^{1-\sigma} \\ -\delta^{1-\sigma} & 1 \end{bmatrix} \begin{bmatrix} 1 \\ \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \end{bmatrix} \end{aligned}$$

$$\begin{aligned} p_1^{1-\sigma} &= \frac{1}{1-\delta^{2(1-\sigma)}} \left(1 - \delta^{1-\sigma} \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}}\right) \\ &= \lambda \end{aligned}$$

so

$$p_1 = \lambda^{\frac{1}{1-\sigma}}$$

then

$$\frac{1}{1-\beta} \beta^{-\frac{\beta}{1-\beta}} \lambda^{-\frac{1}{1-\sigma}\frac{1}{1-\beta}} = S_1$$

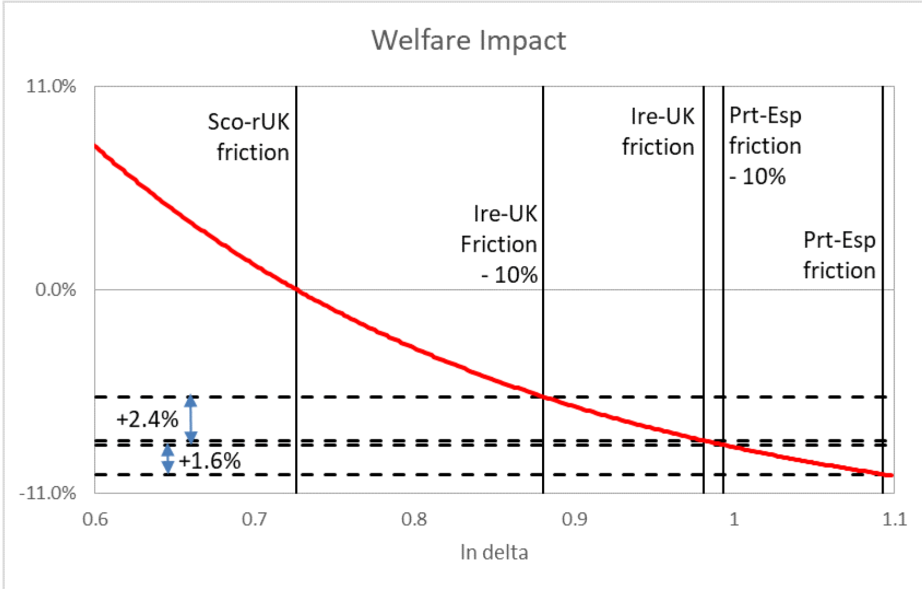

Figure 9: Scottish real income as a function of the trade friction with the rest of the UK. Imposing measured Scot-rUK frictions implies no change in Scottish income relative to the data. Note that infinite frictions with the rest of the UK is not an autarkic Scotland, frictions with the rest of the world are as measured in the data.

- Policy experiment is $\delta \to \infty$
- In this case $p_1 = 1$ so

$$
\begin{aligned}
Y_1' &= S_1 (1-\beta)(\beta)^{\frac{\beta}{1-\beta}} \\
&= \lambda^{-\frac{1}{1-\sigma}\frac{1}{1-\beta}}
\end{aligned}
$$

- i.e. welfare change is

$$
\begin{aligned}
\left(\frac{Y'}{Y}\right) - 1 &= \lambda^{-\frac{1}{1-\sigma}\frac{1}{1-\beta}} - 1 \\
&= \left(\frac{1}{\lambda}\right)^{\frac{1}{(1-\beta)(1-\sigma)}} - 1
\end{aligned}
$$

H The incentive to integrate

In this appendix we note that income is a convex function of bilateral frictions. Figure 9 shows the level of GDP implied by the model for Scotland as a function of log frictions with the rest of the UK, relative to the GDP that it has with current frictions. An intuition behind this convex shape is that it must clearly asymptote to a horizontal line as frictions get very large and you approach zero bilateral trade: the change from nearly infinite frictions to very large but not so large frictions will not change trade patterns much once you are not trading at all. Conversely, the change from medium to small frictions may have a large impact on trade patterns and hence income.

When two entities are closely integrated (due to high affinities, say) the marginal benefit of further integration (via political union, say) is larger than it is for entities which are not so closely integrated (with lower affinities). This supports a selection mechanism whereby pairs with otherwise lower frictions have a greater incentive to form a unified country than those pairs with higher frictions. Trade models, in the general class of gravity models, imply greater integration benefits from marginal reductions in frictions for entities that already have low frictions.

As an example, in Figure 9 we plot the log frictions that Ireland has with the UK, that Portugal has with Spain, and the impact that imposing these frictions has on Scottish income. Suppose that political integration is associated with a reduction in log frictions of size $I = 0.1$. Then, as can be seen, the income gain, +2.4%, is higher if we start at the less frictional Ireland-UK position, than if we start at the more frictional Portugal-Spain position, in which case it is +1.6%.

This lends additional support to the proposition that there will be selection into state sharing and that econometric estimates of the average difference between regional and international borders is not appropriate for determining the value of the economic integration generated by political integration.