The Gains from Economic Integration

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Abstract

This paper measures the effect of sharing a national state on the degree of trade integration. We call the causal effect of this political integration *the economic integration* - this is the additional trade integration gained by entities which come together to form a country rather being independent countries. The existence of very large border effects, even within the European Union, is well known, and is a consequence of this aforementioned economic integration achieved within national states. Nevertheless, there are two potential reasons why these border effects could overestimate the gains from sharing a state. First, there could be a substitution of frictions: by integrating within a state, there could be a deterioration of links to the rest of the world. We see that this is not the case. Secondly, there could be an issue of endogenity and selection bias: places which share larger affinities are more likely to both trade with each other and to select into sharing a state. We conclude that this is an important issue and so this endogeneity means that estimates of the average border effect overstate the reductions in trade frictions achieved by sharing a state. To deal with this endogeneity problem we propose an alternative approach. We identify marginal regions (regions which could conceivably be independent countries by themselves) and marginal countries (countries that are the closest trading partner in the data to the country to which that marginal regions belong). We propose that the gap in trade frictions between these marginal regions and marginal countries is a much better estimate to the causal impact of state sharing. Even controlling for selection bias, we find that the gains from economic integration are still substantial: it is about one third of the total gains from trade.

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

1. Introduction

The aim of this paper is to measure the effect of sharing a national state on the degree of trade integration, and to quantify its welfare implications. We define *economic integration* as the causal effect of this political integration - this is the additional trade integration gained by entities which come together to form a country rather being independent countries. Our contribution lies in that *economic integration* thus defined is not the same as the border effect as it is normally understood.

It is easy to understand that a consequence of the *economic integration* achieved within national states is the existence of very large border effects (trade being much larger within than across national borders). The existence of very large border effects, even within the European Union, is well known, and in this paper we also find large average border effects[1]. To do so, we calibrate interregional and international trade and income data in a general gravity model, and obtain the implicit trade frictions that would explain the observed data, something often referred to as the Head Ries Index (HRI)[2]. 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. The average border effect is then the average difference between the interregional and the international frictions, controlling for physical distance, commona language, and size.

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 state. This endogeneity therefore means that estimates of the average border effect overstate the reductions in trade frictions achieved by sharing a state.

For instance, the fact that Scotland and England share a country is related to the fact that they

[1]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).

[2]According to Head and Mayer (2013), Eaton, Kortum, Neiman, and Romalis (2011) coin the label "Head-Ries Index" since this "indicator first appears in Head and Ries (2001)".

trade a lot - but it is not all causal. 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. To impute the difference between the current Scotland-England frictions with the average frictions that the UK has with other countries as the benefits of economic integration is likely to grossly overestimate the potential trade benefits of a political union.

Our approach to deal with this endogeneity problem has a certain resemblance to regression discontinuity analysis. We identify *"marginal regions"*, defined as regions that could plausibly be an independent country. We also identify *"marginal countries"*, defined as the countries that has the smallest frictions with the country to which the "marginal region" currently belongs. We then study the effects of the counterfactual exercise consisting in substituting the frictions that the "marginal region" has with the country to which belongs for the the frictions that the "marginal country" has. These effects 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. As we will see this is plausibly the case. Marginal regions are identified as regions with substantial independence movements of which there are four in our data: Scotland, Catalonia, the Basque Country, and Quebec. For example we use the difference between 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) as a measure of economic integration. 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.

Another issue that needs to be considered is the potential for regions to substitute intgeration with the rest of their country in place of close links with the rest of the world. For the marginal regions in our analysis, we show that this is not the case and that the frictions that these regions have with the rest of the world is in line with their expected values. In this sense, economic integration is a gain: it is not achieved at the expense of higher frictions with the rest of the world.

Welfare impacts can easily be quantified following the contribution of Arkolakis, Costinot, and Rodríguez-Clare (2012) who show that the total welfare gains from trade, subject to parameters, are the same in all trade models within the class of 'gravity models', and given by a simple formula[3]. 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[4]. In this paper we evaluate the welfare impacts of changing frictions by the magnitude measured between our marginal regions and marginal countries as a good estimate of the causal impact of state sharing. We find that, for all the examples that we look at, the difference for marginal regions in having their measured interregional frictions and the smallest measured international frictions, accounts for about one third of the total gains from trade relative to autarky. This is irrespective of the particular gravity model used (within a subset of the gravity model class), and highly insensitive to the chosen value for the trade elasticity parameter.

Therefore, despite an average econometric estimation exercise likely over-estimating the causal

[3]Though particular microfoundations are suggestive of particular values for the trade elasticity parameter and so do matter, a point made by Melitz and Redding (forthcoming). 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 different values, for the trade elasticity. Simonovska and Waugh (2013) estimate different values for the trade elasticity based on different structural models.

[4]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 (2013) provide a toolkit for implementing such policy experiments in general equilibrium.

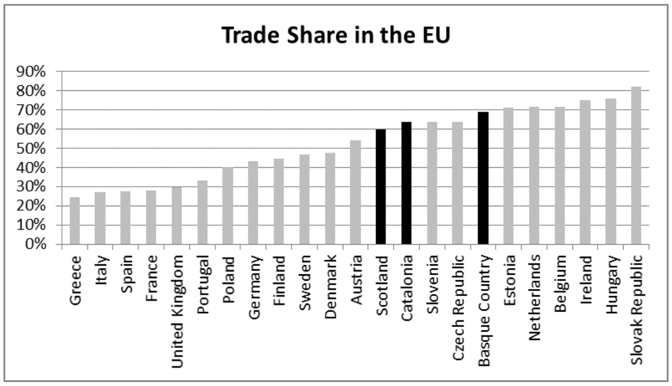
effect of political integration on economic integration, the value of such economic integration even controlling for this over-estimation is still seen to be substantial. We do not explain the institutional arrangements or mechanisms that lead to economic integration within countries, we simply identify the size of this integration, and quantify its importance 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, home bias in preferences, regulation favouring local firms, political economy biases, migratory patterns, network formation, etc. In this paper we simply point the facts and leave the investigation of potential causes to further research[5].

We begin our analysis with a graphical way of seeing that something happens within countries that is different from what happens across countries: the patterns of trade for regions that very plausibly could be 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 of the EU. Scotland, Catalonia, and the Basque Country could be countries, but if they were we would not expect to see their trade patterns be as shown in Figure 1. These regions, viewed as if they were countries, appear to be highly integrated into the global economy with a high share of trade in GDP, however this trade is extremely concentrated with the rest of the country of which they are currently part. Figure 1a[6] 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[7] against GDP on the x-axis, since we may expect small countries to trade more, and concentrate this trade with their large neighbours. We would expect regions to have relatively high index values, as they are relatively small, but not nearly as high as we observe. The regional Herfindahl Indices are much higher than that of the most trade concentrated independent

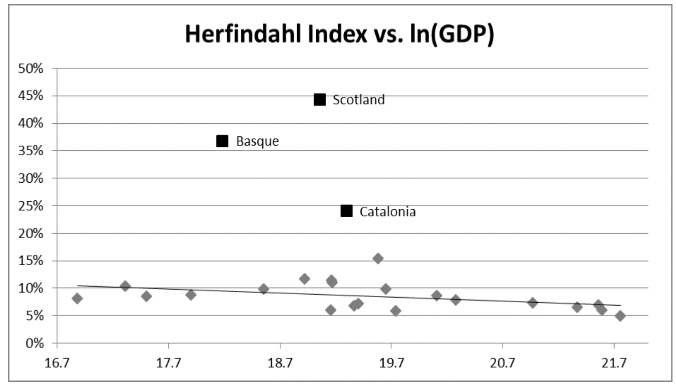
[5] A recent literature on internal frictions is also helpful in moving forward this research agenda, for example Atkin and Donaldson (2014), Cosar, Grieco, and Tintelnot (2014), and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2014).

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

[7] If there are N countries, with the exports from country i to country j denoted X^i_j ($X^i_i \equiv 0$), then the Herfindahl Index for country i, $H_i = \sum_{j=1}^{N}[(X^i_j/\sum_{k=1}^{N}[X^i_k])^2]$. $H_i = 1$ indicates complete concentration of trade with a single trading partner. $H_i \to 0$ (equality only possible with infinitely many possible trading partners) indicates complete diversification of trade across all partners.



(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

EU member[8]: it's almost an order of magnitude type comparison. Our exercise will consist of building reasonable counterfactuals for these regions where they appear as a 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. Our quantitative analysis of the gains from economic integration is conducted in Section 4 in which we show that, even after allowing for this selection bias, a substantial causal impact remains. Section 5 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, is very large - of the order of 35% under a standard set of parameters. A difference of this magnitude has quantitatively significant welfare

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

implications if it is interpreted as the causal effect of national rather than regional borders.

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, a common language dummy, and a regional border dummy. The Head Ries Index (HRI) is the well known indicator of trade frictions implied by all gravity models of trade, it is the friction that would produce the observed bilateral trade within such a gravity model (for a certain trade elasticity). It is a very natural and theory compatible measure of trade frictions, and has been used many times in the literature[9]. It is given by the following expression, where ϵ is the trade elasticity.

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

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

Data & Methodology

The data used in this paper is fully described in Appendix A. But briefly it is: international data from the OECD database covering both goods and services; regional data for the USA, Canada, Spain, and Scotland, is taken from local statistical agencies; all the data is all from years 2005 - 2007 (recent but not so recent as to be subject to further revision and unaffected by disruptions due to financial crisis from 2008 onwards). The following procedure is followed to construct an internally consistent dataset:

- From data we have: X_j^i, the trade flow from i to j; and GDP_i.

[9]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 (2011), 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 bilaterally balanced trade, which is appropriate here because we create a dataset with notional measures of bilateral trade which imply that all trade is bilaterally balanced.

- Then define:

$$
\begin{aligned}
X_{ij} &= \frac{1}{2}\left(X_i^j + X_j^i\right) \\
X_{ii} &= GDP_i - \sum_{j \neq i} X_j^i \\
Y_i &= \sum_{j=1}^{n} X_{ij}
\end{aligned}
$$

- For the countries in our data, the data obtained using the above is used directly.

- 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, Y, the share of external trade, and the ratio of internal trade to external trade, implied by the regional dataset, to the income, Y, and the international trade from the country dataset.

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 and Scotland despite goods and services data being available. 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 proceedure. But we can infer in which direction it biases our results from the Canadian data, and it seems to matter quantitatively - we will come back to this. In Section 4 we use goods and services data for Scotland, Quebec, Catalonia, and the Basque Country[10].

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 (2013) and Melitz and Redding (forthcoming)) about the appropriate value for the trade elasticity, but

[10]It is in itself interesting that out of all the autonomous communities of Spain, the regions with substantial independence movements, Catalonia and the Basque Country, are the only two with their own local statistical agencies that produce goods and services data.

based loosely on Simonovska and Waugh (2013), for this exercise we choose $\epsilon = -3.5$[11]. In the Section 4 we will reach a conclusion that is extremely insensitive to this choice.

Average Border Effect Results

We take logs of the set of calculated HRIs and regress against income, distance, and common language. These results are shown in Table 1. 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 (see Appendix B for the results of these regressions).

Left Hand Side: ln HRI	Coefficient	t-statistic
distance (km)	0.0000541	24.2
common language dummy (= 1 if have an official language in common)	−0.270	−5.7
$\ln Y_i + \ln Y_j$	−0.0777	−14.0
regions dummy (= 1 if regional border)	−0.345	−6.0
constant	4.30	19.6

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

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 countries and regions. As can be seen, the regional frictions are generally lower than 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).

An interesting but separate point to our main discourse is to examine this negative relationship of measured frictions upon the size of the parties. This does not impact upon our main point, which is the average border effect, because we report this conditional on size. The dependence of frictions upon size however does not, *a priori*, have an obvious sign, and we investigate the

[11] Simonovska and Waugh (2013) 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 figure is somewhere in the middle of this range and close to the figure of −3.41 appropriate given the Melitz (2003) model.

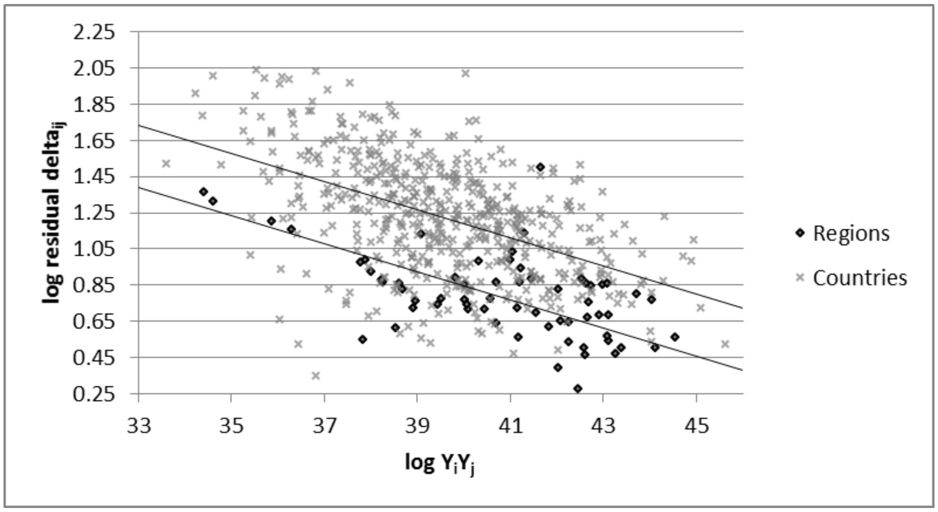


Figure 2: Scatter plot showing bilateral trade frictions against GDP split by countries and regions

systematic negative dependence in Appendix C. There we demonstrate that this slope can be explained purely as a result of aggregation issues. This justifies the definition of "residual delta" in Figure 3 as the measured HRI after controlling for size as well as physical distance and common language (i.e. "residual delta" in 3 is the regression residual plus the impact of the regional dummy). This figure shows that there is almost first order stochastic dominance for regional frictions compared with country frictions.

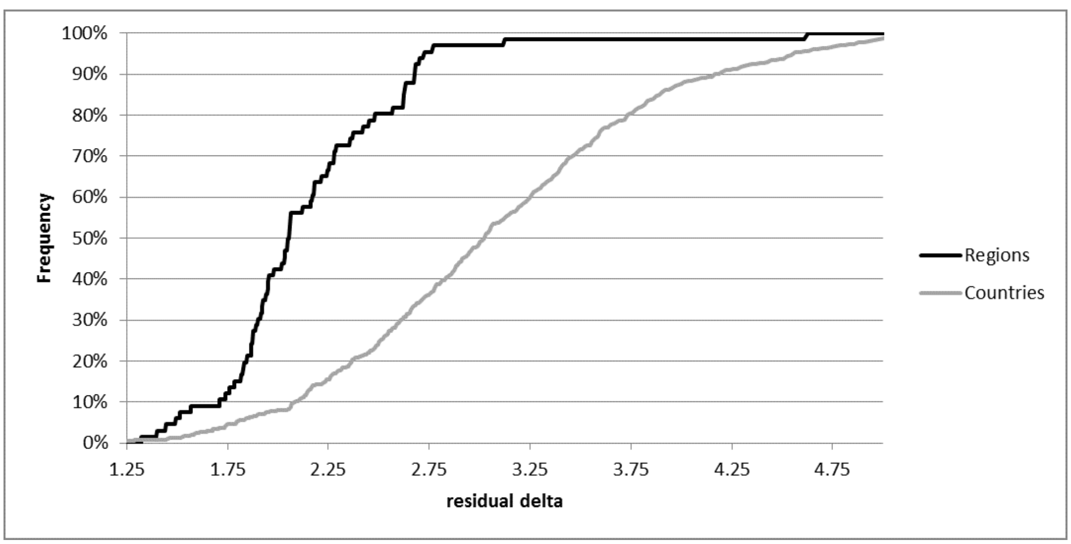


Figure 3: Empirical CDF of residual trade frictions between regions and between countries

The difference between the two 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 interregional friction. In fact we believe that the average border effect is even larger than the 34.5% coefficient from 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.

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 will be conservative: it will understate 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 Scotland, Catalonia, and the Basque Country. Therefore we can calculate the HRIs based on both a goods only apportionment of the Canadian, Spanish and UK 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 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 higher in every case.

Region	Measured HRI	
	Goods Only Data	Goods & Services Data
Newfoundland	2.23	1.89
Prince Edward Island	2.68	2.32
Nova Scotia	2.14	1.96
New Brunswick	2.00	1.66
Quebec	1.73	1.53
Ontario	1.66	1.41
Manitoba	2.01	1.75
Saskatchewan	2.06	1.71
Alberta	1.85	1.58
British Columbia	1.98	1.73
Yukon	3.33	2.95
Northwest Territories	2.97	2.29
Nunavut	3.55	3.09
Scotland	1.71	1.53
Catalonia	1.66	1.42
Basque Country	2.42	1.53

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

The average of the log differences in frictions for the Canadian provinces[12] is 15%[13].

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 34.5% figure from Table 1. Assuming the Canadian results are representative would imply that the average difference between regional and country frictions are of the order of 49%.

It is therefore the case that the comparison of country-country frictions to regional 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 a significant differences between regional and country level frictions.

[12]The equivalent figures for Scotland, Catalonia and the Basque country are also shown in Table 2. However, for the Spanish autonomous communities, the goods only numbers are derived from Spanish regional data that is compiled centrally whereas the goods and services figures are derived from locally compiled data. Therefore the difference between these numbers could reflect statistical definitions and methodological differences rather than a true difference caused by a goods only versus a goods and services comparison. An analagous issue afflicts the Scottish figures. The Canadian data for both goods and services and for goods only is downloaded from the same database and so should be a fair comparison. Note that again the numbers shown in Table 2 all depend on the value of the trade elasticity used, here $\epsilon = -3.5$.

[13]Both a simple average and an income weighted average produce a fgure of 15%.

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The body of evidence indicating that regional borders are systematically less frictional than country borders is very substantial: even controlling for physical distance and common language, for any given size frictions are systematically lower among regions than among countries (Figure 2). Controlling also 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.

These large border effects, however, do not imply that the economic integration that could be achieved by sharing a national state is as large as these average differences. For this to be the case, it would have to be that national borders caused trade declines of this magnitude. In reality, who shares and who does not share a state is an endogenous proposition. This endogeneity, and our proposed method to deal with it, is one of the major contributions of this paper, and we turn to this in the next section.

3. Endogenous Country Formation

The estimated average difference between international frictions and interregional 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. This endogeneity means that 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 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 i 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_i and θ_j respectively. We denote whether i and j are part of the same country (political union) by s_{ij}. We say that $s_{ij} = 1$ if they are so, and $s_{ij} = 0$ if they are not part of the same country. The innate characteristics of the entities, θ_i, refer to cultural, social, geographical aspects that escape economic modelling and that we take as exogenous. These are things that, at least from the point of view of an economist, are not altered by trade or by sharing a political union.

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

$$\ln \delta_{ij} = F(\theta_i, \theta_j) + \beta s_{ij} + u_{ij} \tag{2}$$

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

If θ_i and θ_j are independent of s_{ij} there is no problem with the estimation of equation 2. This is what is shown in Table 1, where $F(\theta_i, \theta_j)$ is the geographic distance between i and j and a dummy on whether they share a state. The OLS estimated value of β is then -0.345.

This estimation has two probems, 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 regional trade. It is trivial because, insofar as those missing characteristics are orthogonal to s_{ij}, the estimation of β remains unbiased.

The substantial problem is that those characteristics (missing or not) are very likely to be correlated with s_{ij}: which entities select into being a country is far from an exogenous proposition. The probability of the event $s_{ij} = 1$, 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_{ij}.

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 that the probability of $s_{ij} = 1$ is a function of $F(\theta_i, \theta_j)$.

$$Prob(s_{ij} = 1) = G(F(\theta_i, \theta_j))$$

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

Given that the problem lies in determining the function $Prob(s_{ij} = 1) = G(\theta_i, \theta_j)$, an intuitive approach for solving this problem is to look at the break-up of nations in a manner not unlike a regression discontinuity analysis. 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[14]. 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.

Our approach to control for this endogeneity is also a form of regression discontinuity analysis

[14]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).

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 i be such a marginal region, j be the associated marginal country, R be the country of which i is a part, and r be the rest of this country other than i (this is, $R = r \bigcup i)$. Then our assumption is that $F(\theta_i, \theta_r) \approx F(\theta_j, \theta_R)$ and thus, $\beta \approx \ln \delta_{jR} - \ln \delta ir$. 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.[15]

We define "marginal" regions as regions with a strong and credible independence movement. There are four such regions in our dataset: Scotland, Catalonia, the Basque Country, and Quebec[16]. 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 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

[15]In any case, in 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).

[16]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. Quebec has held two referenda on independence from Canada, the last in 1995 in which 49% voted for independence.

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.

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 gravity model to evaluate the impact that this conterfactual experiment has upon income, and label this as the gain from the economic integration that is **caused** by sharing a state.

4. Results

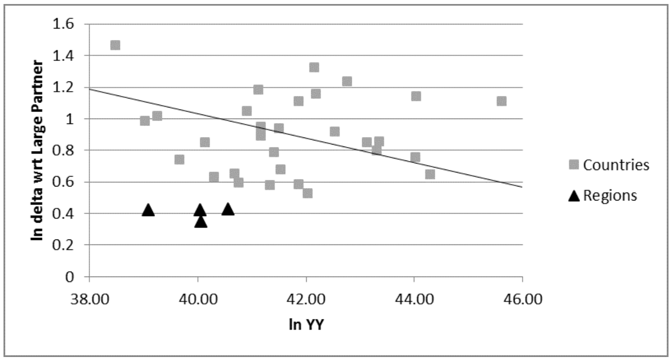
In this section we evaluate the welfare consequences of policy experiments applied to the “marginal regions” of Scotland, Catalonia, the Basque Country, and Quebec. We evaluate the cost to these regions of having international borders with the rest of the country of which they are part, both using the 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 history of the literature on the border effect has reduced its importance, with McCallum (1995) showing a much stronger effect than Anderson and van Wincoop (2003). 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, our estimates are 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 quarter and a half of the total gains from trade, relative to autarky, enjoyed by the regions that we consider.

4.1. No Substitution

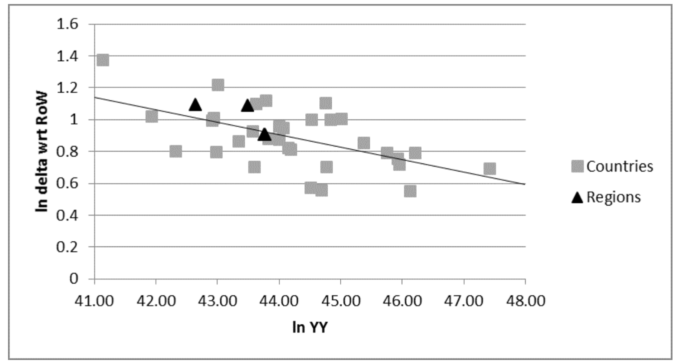
Before we conduct our counterfactual policy experiments, we consider another reason why the difference between international and interregional frictions (both calculated as the econometric average, or as the difference between marginal countries and marginal regions) could over-estimate the causal impact of political integration upon economic integration. A Nordic proverb says that you need to visit the houses of your friends, otherwise grass ends up covering their paths. With that in mind, it could be thought that regions have such smaller 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 closer ones with him, but by not interacting with others, you get further apart from them. In such a case the role of the state 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 four 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 triple then becomes the country, its largest trading partner, and the rest of the world. The results are presented in Figures 4a and 4b. The slopes in these graphs is the regression coefficient on size from Table 1. 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 largest trading partner (which is the rest of their nation).

Regions differ from countries in the frictions that they have with their main partner, 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. It does not seem to be the case that regions are substituting very close trade links with the rest of their



(a) Regions are better than expected at trading with their largest 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

country for slightly closer trade links with all possible partners in 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. Therefore, at the present time[17], the integration benefits of sharing a nation are apparently additional to the normal integration benefits that countries enjoy within the global economy.

4.2. Counterfactual exercises

In order to proceed, we need a model in which we can conduct counterfactual analyses. Arkolakis, Costinot, and Rodríguez-Clare (2012) show that there is a map from trade elasticity, ϵ, and home share, λ, to welfare changes, ΔW, in all "gravity models", and we have seen that there is a map from trade flows to the HRI measure of trade frictions implied by such gravity models. We propose to implement policy experiments by changing the HRI measure of trade frictions. However, to quantify the welfare change under these policy experiements, we need to know how the trade flows vary with the HRIs. Unfortunately, as shown in Appendix D, there is no general map from HRIs to trade flows and a model is needed to provide the necessary structure for a specific set of HRIs to imply a specific set of counterfactual trade flows and incomes. The Arkolakis, Costinot, and Rodríguez-Clare (2012) formula only allows the welfare change to autarky to be evaluated - since it is only under autarky that we know the value of the counterfactual home share, $\lambda' = 100\%$.

[17]We do not say that e.g. the EU could not in the fullness of time come to resemble a United States of Europe, just that it does not look like this currently.

$$\Delta W = \left(\frac{\lambda'}{\lambda}\right)^{\frac{1}{\epsilon}} - 1$$

Costinot and Rodríguez-Clare (2014) state that gravity models in which fixed exporting costs (if any) are paid in the destination country have a stronger equivalence result. In this case, counterfactual changes in trade flows are exactly the same as in the Armington model. Since this equivalence result holds across a fairly wide class of common models used in the international trade literature, it is a natural benchmark to consider. We therefore compute our counterfactual scenarios using the Armington model (see Appendix E)[18].

We have detailed regional data, including trade in services, for Scotland, Catalonia, the Basque Country, and Quebec as described in Appendix A. We find counterfactual countries for these "marginal regions" by identifying the least frictional trading partner, the "marginal" country, with respect to Spain (as a counterfactual for both Catalonia and the Basque Country) and with respect to the UK (as a counterfactual for Scotland). We do this by first running the simple gravity regressions:

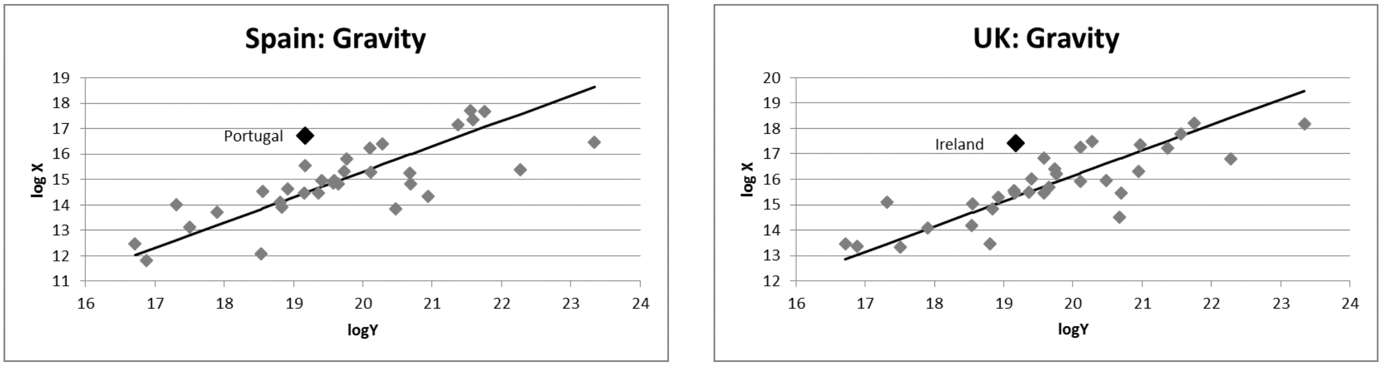
$$\ln X_i = \alpha + \ln Y_i + \epsilon_i$$

where X_i is the average of imports and exports to and from Spain or the UK with country i, and Y_i is the national income measure of country i. The independent country that is chosen as the counterfactual for the corresponding region is the country with the highest residual in these regressions. As shown in Figures 5a & 5b, these countries are Portugal and Ireland respectively.

As shown in Figure 6a, the "marginal country" with respect to Canada is the USA, which given size effects, has a border with Canada that is a highly unsuitable international counterfactual for Canadian interregional borders. A more suitable entity to use is a state in the USA as a counterfactual for Quebec. We consider the range of US states whose GDP is within 20% of Quebec's[19] and find (Figure 6b) that the state with the lowest gravity residual for trade with Canada from

[18]Consistent with the claim in Costinot and Rodríguez-Clare (2014) that the results from the Armington Model hold in a wider equivalence class of models, the calculations in this version of the paper are unchanged from a previous version, Comerford and Rodríguez-Mora (2014), in which we used the Melitz (2003) model.

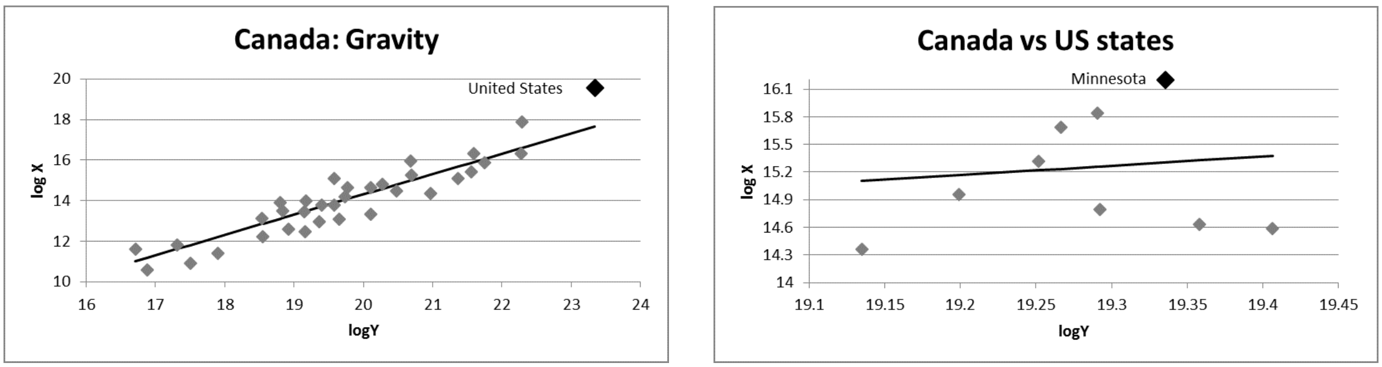
[19]These states are Louisiana, Connecticut, Missouri, Wisconsin, Tennessee, Colorado, Minnesota, Arizona, Indiana, and Maryland.



(a) Regression of log trade flows with Spain on log GDP

(b) log trade flows with the UK on log GDP

Figure 5: Gravity equations of UK and Spain



(a) Regression of log trade flows with Canada on log GDP

(b) log trade flows with the Canada on log GDP

Figure 6: Gravity equations of USA and Canada

this set is Minnesota. We therefore use Minnesota's measured trade frictions with Canada as the counterfactual "marginal country" frictions for assessing Quebec's gains from integration within Canada[20].

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 (see Appendix G for an analysis of the quality of the counterfactuals).

The "Average Impact" HRI is the measured HRI for the Region-Rest of Country pair adjusted by the average border effect of 49% (coefficient on regional borders from Table 1 augmented by the average (Canadian) trade in services impact relative to the data used for the econometric exercise, Table 2). Let i be the region, j be the counterfactual, R be the country of which i is a part, and r be the rest of this country other than i. Then we measure δ_{ir} and δ_{jR} from trade data, and define

[20] Actually, we use a modified version of the measured Minnesotan friction. This modification is due to the goods only nature of the US regional data, and is explained in Appendix F.

$\delta_{ir}^{ave} = \exp(\ln \delta_{ir} + 49\%)$.

	Trade Frictions			Welfare Impact	
	δ_{ir}	δ_{jR}	δ_{ir}^{ave}	δ_{jR}	δ_{ir}^{ave}
Scotland (Ireland)	1.53	1.81	2.51	-6.8%	-12.5%
Catalonia (Portugal)	1.42	2.34	2.33	-9.9%	-9.9%
Basque C. (Portugal)	1.53	2.34	2.51	-13.2%	-14.0%
Quebec (Minnesota)	1.53	2.27	2.50	-6.5%	-7.2%

Table 3: Imposing HRIs on regions, with trade elasticity $= -3.5$

Table 3 shows the measured HRIs for the marginal regions with respect to the rest of the country of which they are part, the HRIs imposed on these pairs as policy experiments, and the welfare impact on the marginal regions of performing these policy experiements. The welfare impacts based on the counterfactual marginal countries are lower than the impact of imposing the average difference between country and regional frictions for Scotland and Quebec, and approximately equal for Catalonia and the Basque Country. Every figure in this table is of course sensitive to the value chosen for the trade elasticity, here $\epsilon = -3.5$ as before (the equivalent figures for alternative trade elasticities are shown in Appendix H).

We rationalise this variation in the impact of the marginal region - marginal country difference across countries as another point in favour of our proposed method: not only does this method do as good a job as we are able to do in dealing with this selection bias, it also controls in some respects for institutional details and country fixed effects. For instance, the fact that the integration benefit to Spanish regions in being part of Spain is seen to be approximately the same as the econometrically derived "Average Impact" is a consequence of Spain not being very open to other independent countries, and the average difference between its internal and external frictions is much larger than the difference between regional and international frictions averaged over the whole dataset. The difference between the frictions between its marginal regions, Catalonia and the Basque Country, and the rest of Spain, and between Spain and its marginal country, Portugal, is our best estimate of the integration benefit enjoyed by Catalonia and the Basque Country, and it is substantially larger than the integration benefit enjoyed by Quebec and (especially) Scotland because Canada and (especially) the UK and are "better" at external trade than is Spain.

As well as being sensitive to the value chosen for the trade elasticity, there does not seem to

	Home Share	Home Share Counterfactual			Welfare Impact / cost autarky		
	Data	$\epsilon = -2.8$	$\epsilon = -3.5$	$\epsilon = -5.2$	$\epsilon = -2.8$	$\epsilon = -3.5$	$\epsilon = -5.2$
Scotland (Ireland)	40%	51%	51%	52%	30%	30%	29%
Catalonia (Portugal)	36%	52%	53%	53%	40%	40%	39%
Basque C. (Portugal)	31%	51%	51%	51%	47%	47%	46%
Quebec (Minnesota)	42%	53%	53%	53%	30%	30%	29%

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

be much common ground between the welfare figures in Table 3. However, in Table 4 we express the results of imposing the marginal country friction, δ_{jR}, as a counterfactual home share of trade in GDP, and the welfare loss as a share of the total welfare loss on autarky, for a range of values of the trade elasticity. We see 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 quarter 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.

Our results can be seen to be consistent with those reported in Anderson and van Wincoop (2003). Table 5 shows the change in bilateral trade flows (these figures are insensitive to the value of the trade elasticity[21]). Anderson and van Wincoop (2003) reports that bilateral trade falls by 81% when borders are imposed between entities[22] The exercise undertaken in Anderson and van

[21] Or certainly, the change in bilateral trade seen when the measured HRI for the counterfactual marginal country is imposed upon the region-rest of country pair, is insensitive to the value of the trade elasticity.

[22] Considering Anderson and van Wincoop (2003)'s "ROW-ROW" figure, imposing international borders in an otherwise borderless world causes trade between any two parties to change by a factor of 3.71 due to the imposition of borders with third parties, and to change by a factor of 0.19 due to the direct effect of the imposition of the bilateral border.

	$(X'_{ij}/Y'_i)/(X_{ij}/Y_i)$	
	Counterfactual	Average Impact
Scotland (Ireland)	64%	23%
Catalonia (Portugal)	22%	22%
Basque C. (Portugal)	30%	24%
Quebec (Minnesota)	29%	21%

Table 5: Ratio of bilateral trade in policy experiments to that seen in the data

Wincoop (2003) is akin to the "Average Impact" column in Table 5, and we see that here too bilateral trade falls by nearly 80% when the average impact of borders is imposed upon entities[23].

4.3. The incentive to integrate

Finally for this section, we note that income is a convex function of log bilateral frictions, and this supports the selection mechanism whereby entities with otherwise lower frictions have a greater incentive to form a unified country than those entities with higher frictions. Figure 7 shows Scottish income as a function of log frictions with the rest of the UK. In addition the log frictions that Ireland has with the UK, and the log frictions that Portugal has with Spain, as well as the impact that imposing these frictions on the Scotland - rest of the UK relationship has on Scottish income, are shown. Suppose that political integration is associated with a reduction in log frictions of size I. Also shown are the impact on income if both the Ireland-UK and the Portugal-Spain friction are reduced by $I = 10\%$. As can be seen, the income gain is higher if we start at the Ireland-UK position, +3.5%, than if we start at the Portugal-Spain position, +1.5%.

This shows that, even if there were no Alesina, Spolaore, and Wacziarg (2005) style *costs of heterogeneity*, trade models alone imply greater intergration benefits from a fixed percentage reduction in frictions for entities that already have low frictions. This lends additional support to the proposition that there will be selection into state sharing and that econometric estimates of the

[23]The exercise of Anderson and van Wincoop (2003) is not exacty the same as performed here, but it should be analogous: our figures are imposing an international border between two regional parties in the context of a world with pre-existing international borders. Their exercise is to impose international borders in an otherwise borderless world. If we suppose that their figure of 3.71 is the ratio of X_{ij} given the frictions in the data, to X_{ij} given a frictionless world; and that their figure of 0.71 is the ratio of X_{ij} given the frictions in the data with the added friction of an international border between i and j, to X_{ij} given a frictionless world; then we can cancel out the frictionless X_{ij} to get 0.19 as the ratio of X_{ij} given the frictions in the data with the added friction of an international border between i and j, to X_{ij} given the frictions in the data.

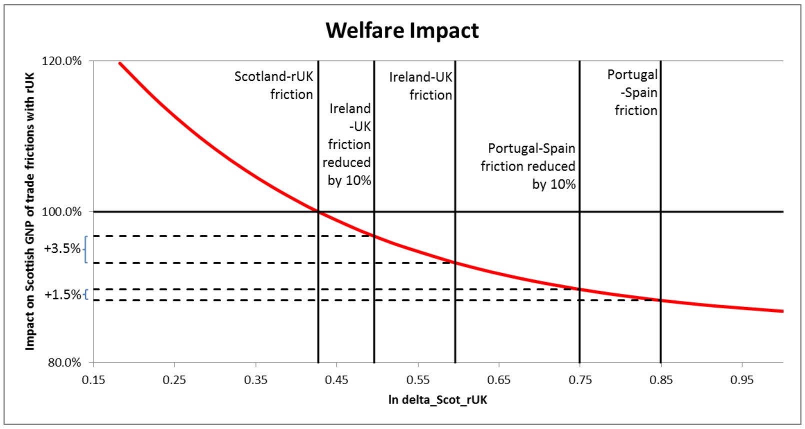


Figure 7: Scottish real income as a function of the trade friction with the rest of the UK. Imposing measured Scot-rUK frictions implies income at 100% of its value in the data. Note that infinite frictions with the rest of the UK is not an autarkic Scotland, frictions with the rest of the world are as measured in the data.

average difference between regional and international borders is not appropriate for determining the value of the economic integration generated by political integration.

5. 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). In gathering this evidence, we show that the standard measure of trade frictions that comes out of most modern trade models, the Head Ries Indicator, is a function of the size of the bilateral trade parties, or of degree of aggregation in the data considered (Appendix C). Further we show that the available evidence suggests that trade in services is more home biased than trade in goods (Table 2). Our econometric exercise controls for these effects, and it 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) in standard gravity models of trade (Table 3). It can be seen that the estimates produced in this way are consistent with previous literature (in that the bilateral trade fall in the "Average Impact" column of Table 5 is consistent with the trade falls reported in Anderson and van Wincoop (2003)).

However, we believe that this "average" border effect overestimates the impact of sharing a state: most models of endogenous state formation have the costs of state sharing related to population heterogeneity which is likely correlated with the trade frictions that we measure. 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. We provide another mechanism in support of this selection mechanism when we show (Figure 7) that, if the integration benefit is a fixed percentage reduction in frictions, then entities with otherwise lower frictions stand to receive a higher welfare benefit from this fixed percentage reduction in frictions.

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. By controlling for this selection bias, we reduce the estimated integration benefit in the case of Scotland within the UK, and to a lesse extent in the case of Quebec within Canada. We observe that this method of determining a counterfactual produces similar integration benefits as seen in using the econometric "Average Impact" for Catalonia and the Basque Country within Spain (Table 3).

We rationalise this as another point in favour of our proposed method: not only does this method do as good a job as we are able to do in dealing with this selection bias, it also controls in some respects for institutional details and country fixed effects. For instance, the fact that the integration benefit to Spanish regions in being part of Spain is seen to be approximately the same as the econometrically derived "Average Impact" is a consequence of Spain not being very open to other independent countries, and the average difference between its internal and external frictions is much larger than the difference between regional and international frictions averaged over the whole dataset. The difference between the frictions between its marginal regions, Catalonia and the Basque Country, and the rest of Spain, and between Spain and its marginal country, Portugal, is our best estimate of the integration benefit enjoyed by Catalonia and the Basque Country, and it is substantially larger than the integration benefit enjoyed by Quebec and (especially) Scotland because Canada and (especially) the UK and are "better" at external trade than is Spain.

The history of the literature on the border effect has reduced its importance, with McCallum (1995) showing a much stronger effect than Anderson and van Wincoop (2003). 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 independent of model specification across a broad class of simple models from modern trade theory, and they tell the same story across the four examples that are in our data set: the gains from economic integration that come with political integration are worth between a quarter and a half of the total gains from trade, relative to autarky, enjoyed by these regions (Table 4).

Of course, this claim to generality does need to be qualified by noting that we have used the basic gravity model (though this covers many underlying sets of microfoundations for trade). A richer model, for example multisectors, intermediate goods, multiple factors of production, mobile factors of production etc (see Melitz and Redding (forthcoming) for an example of such a model, and Costinot and Rodríguez-Clare (2014) for a survey of this literature) would not necessarily produce a different result though. A richer model that was still represented by a constant trade elasticity would produce a similar conclusion (though of course such a model could imply radically different trade elasticities from those considered here which would obviously strongly affect the estimates in Table 1) since a counterfactual analysis of this sort will always produce a similar welfare change as a proportion of total gains relative to autarky. If trade elasticity fell as economies became more isolated (which also seems plausible) so that trade became infinitely valuable as autarky was approached for a very small economy, then clearly we would need to find another way to express the results in this paper.

We are, to our knowledge, the first to report that large border effects are not a result of "substituting" frictions. The integration benefit regions have with the rest of the country (4a) of which they are part is not compensating for low levels of integration with the wider world: Figure 4b shows that their measured frictions with the rest of the world are in line with the expected frictions, based on size, that all the OECD countries have with the rest of the world excluding their largest trading partner. Thus, large border effects do not arise because regions enjoy low frictions with the rest of the country they form part *at the expense* of higher frictions with the rest of the world. This, finally, allows us to explain, in terms of measured parameter values, the Herfindahl charts (Figure 1b) presented in Section 1. The regions do not excessively concentrate their trade with the rest of the country of which they are a part because they find it difficult to trade with the rest of the world, rather their trade is concentrated because they have such low frictions with the rest of their country. This high level of internal economic integration has a value of between one quarter and one half of the total gains from trade compared to moving all the way to autarky. This does, however, beg the question of future research: exactly what mechanisms create this level of integration within countries?

Over period since the Second World War, international trade has grown in importance and international bodies like the EU, WTO, and NAFTA have sought to promote it. However, despite this progress and despite these institutions, the results presented in this paper suggests that there is still a gap between the levels of integration seen within countries as opposed to that seen between countries. The implications of this are both that perhaps there is scope for much greater integration between countries, with quantitatively significant benefits. And perhaps political independence for regions, even within institutions like the European Union, may lead to a material reduction in the degree of economic integration these regions currently enjoy, again with quantitatively significant implications.

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Appendices

A. Data

The data is all from years 2005 - 2007 (recent but not so recent as to be subject to further revision and unaffected by disruptions due to financial crisis from 2008 onwards).

Country Data

- Have GDP and total (goods and services) bilateral trade flows for 2006 from the OECD

$$GDP_i \ \& \ X_j^i, \forall i \ \& \ \forall j \neq i$$

- Goods trade from the OECD's "STAN Bilateral Trade Database by Industry and End-use category"
- Services trade from the OECD's "EBOPS 2002 - Trade in Services by Partner Country"
- Consistent GDP measures infered from http://www.oecd-ilibrary.org/trade/exports-of-goods-and-services_exp-gds-serv-table-en and http://www.oecd-ilibrary.org/trade/imports-of-goods-and-services_imp-gds-serv-table-en
- "Rest of the world GDP" infered from the OECD's "Economic Outlook No 93 - June 2013 - Long-term baseline projections"

US Data

- 2007 State GDP as percentage of US GDP, from Bureau of Economic Analysis http://www.bea.gov/itable/
- 2007 bilateral trade flows (goods only) between states and internationally from the Freight Analysis Framework http://faf.ornl.gov/fafweb/Extraction0.aspx
- State GDP for use in the model is taken to be the US GDP from the Country data above multiplied by the state percentage of total GDP from this dataset
- State exports to other states and internationally, for use in this model, is taken to be US international exports from the country data above multiplied by the individual trade flow from this dataset divided by total US international exports from this dataset.

Canadian Data

- 2006 Data from Statistics Canada, Table 386-0002 Interprovincial and international trade flows at producer prices http://www5.statcan.gc.ca/cansim/a05?lang=eng&id=3860002
- This gives bilateral trade flows (either goods only, or goods and services) between provinces and internationally, as well as provincial GDPs
- Provincial GDP for use in the model is taken to be the Canadian GDP from the Country data above multiplied by the provincial share of total GDP from this dataset

- Provincial exports to other provinces and internationally, for use in this model, is taken to be Canadian international exports from the country data above multiplied by the individual trade flow from this dataset divided by total Canadian international exports from this dataset.

Spanish Data

- 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_Interregional_en_Espa%C3%B1a_1995-2006_29_10_08.pdf)
- A matrix of goods only bilateral trade flows between Autonomous Communities from C-Intereg statistics query: "Filas: CCAA origen: Todos; Columnas: Unidades; CCAA destino: Todos; Flujo: Inter + Intra; Dato acumulado de los años: 2005" on http://212.227.102.53/explotacion_multidimensional_comercio_interregional/estadisticas.aspx
- Autonomous Community GDPs from Eurostat ("Regional gross domestic product by NUTS 2 regions - million EUR, Code: tgs00003"
- Separately, we have goods & services data for Catalonia and the Basque Country.

Autonomous Community Goods only data

- Autonomous Community GDP for use in the model is taken to be the Spanish GDP from the Country Data above multiplied by the Autonomous Community share of total GDP in 2006 from Eurostat data
- The 2006 trade data is used to split Spanish trade with the rest of the world by A.C. and the trade with the rest of Spain is inferred from the comparison between rSpain and RoW trade by A.C. from this table
- The trade with the rest of Spain is split into balateral trade across all A.C.s using matrix of bilateral trade flows

Catalonia

- Use Eurostat GDP split, now as at 2005, to calculate Catalan and rSpain GDP from Spanish GDP from Country Data
- Goods and services trade with rest of Spain and with rest of the world from Comptes econòmics simplificats de l'economia catalana 2005, expressed as % of Catalan GDP allows us to calculate Catalan trade with rSpain and RoW from Catalan GDP
- rSpain trade with rest of the world taken to be Spanish trade from Country Data minus Catalan trade from above
- Split Catalan trade with rest of the world, as calculated above, using data from C-Intereg (Table 4 of http://www20.gencat.cat/docs/economia/Documents/Arxius/doc_14603187_1.pdf) for use in Herfindahl calc

Basque Country

- Use Eurostat GDP split, now as at 2005, to calculate Basque and rSpain GDP from Spanish GDP from Country Data
- Goods and services trade with rest of Spain and with rest of the world 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_i.html#axzz2vHsbZz as % of Basque GDP allows us to calculate Basque trade with rSpain and RoW from Basque GDP
- rSpain trade with rest of the world taken to be Spanish trade from Country Data minus Basque trade from above
- Split Basque trade with rest of the world, as calculated above, by destination for imports and exports from Eustat (http://en.eustat.es/ci_ci/estadisticas/tema_374/opt_0/tipo_1/ti_Foreign_Trade/temas.html#axzz2vHsbZzjn) for use in Herfindahl calc

Scottish Data

- Use GERS (http://www.scotland.gov.uk/Publications/2013/03/1859) ratio of "Scotland - Excluding North Sea GDP" to UK GDP, for 2006-07, to split the UK GDP from Country Data
- Goods and services trade with rest of UK and with rest of the world from Scottish Government's Input-Output tables for 2007 (http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Downloads/IO1998-2009All), expressed as % of Scottish GDP allows us to calculate Scottish trade with rUK and RoW from Scottish GDP
- rUK trade with rest of the world taken to be UK trade from Country Data minus Scottish trade from above
- Split Scottish trade with rest of the world, as calculated above, by destination from Global Connections Survey 2011 data for 2007 (http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Exports/GCSIntroduction/GCS2011pdf) for use in Herfindahl calc

Physical Distance and Common Language Data

- National capital cordinates and official language of nations from http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=6
- Regions always assumed to have a common language with the rest of their country.
- Regional capital coordinates for Scotland and for Spanish autonomous communities obtained from individual google searches.
- Regional capital coordinates for US states from http://bl.ocks.org/sjengle/5315515
- Regional capital coordinate for Canadian provinces from http://www.webtrees.net/index.php/en/add-ons/viewdownload/4/111

B. Regression results under alternative trade elasticities

- Regression results with trade elasticity $= -2.8$

Left Hand Side: ln HRI	Coefficient	t-statistic
distance (km)	0.0000677	24.2
common language dummy (= 1 if have an official language in common)	−0.337	−5.7
$\ln Y_i + \ln Y_j$	−0.0972	−14.0
regions dummy (= 1 if regional border)	−0.431	−6.0
constant	5.37	19.6

- Regression results with trade elasticity $= -5.2$

Left Hand Side: ln HRI	Coefficient	t-statistic
distance (km)	0.0000364	24.2
common language dummy (= 1 if have an official language in common)	−0.182	−5.7
$\ln Y_i + \ln Y_j$	−0.0523	−14.0
regions dummy (= 1 if regional border)	−0.230	−5.9
constant	2.89	19.6

C. 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 income, 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 income Y, and the trade elasticity ϵ, by manipulating Equation (1):

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

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 -0.0777. 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 (2014) 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[24] 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.

D. HRI destroys information: need for a model

Arkolakis, Costinot, and Rodríguez-Clare (2012) show that there is a map from trade elasticity and home share to welfare in all "gravity models", and we have seen that there is a map from trade flows to the HRI measure of trade frictions. We propose to change the HRI measure of trade frictions based on plausible counterfactuals. However, to quantify the welfare change under these counterfactual experiements, we need to know how the trade flows vary with the HRIs. Unfortunately, as we now show, the map from trade flows to HRIs is not bijective and so we need to propose a model to determine our counterfactual

[24] Coughlin and Novy (2011) also make this point.

trade flows. The Arkolakis, Costinot, and Rodríguez-Clare (2012) formula only allows the welfare change to autarky to be evaluated - since under autarky we automatically know what the trade flows must be.

Define

$$x_i(j) = \ln \frac{X_{ij}}{X_{ii}}$$

so

$$x_i(i) = 0$$

and

$$A_{ij} = A_{ji} \equiv 2\varepsilon \ln \delta_{ij} = x_i(j) + x_j(i)$$

Write in matrix form:

$$\begin{bmatrix} 0 & A_{12} & ... & A_{1n} \\ A_{12} & 0 & ... & A_{2n} \\ ... & ... & ... & ... \\ A_{1n} & A_{2n} & ... & 0 \end{bmatrix} = \begin{bmatrix} 0 & x_1(2)+x_2(1) & ... & x_1(n)+x_n(1) \\ x_2(1)+x_1(2) & 0 & ... & x_2(n)+x_n(2) \\ ... & ... & ... & ... \\ x_n(1)+x_1(n) & x_n(2)+x_2(n) & ... & 0 \end{bmatrix}$$

i.e. $A = X + X'$ is a mapping from $n(n-1)$ pieces of information, $\{x_1(2), ..., x_1(n), x_2(1), ..., x_2(n), ..., x_n(1), ..., x_n(n-1)\}$, into $n(n-1)/2$ piece of information, $\{A_{12}, ..., A_{1n}, A_{23}, ..., A_{2n}, ..., A_{(n-1)n}\}$. We can therefore conclude that the HRI destroys some of the trade flow information. In order to recover trade flows from a counterfactual set of HRIs, we need to impose a specific gravity model.

E. Armington Model

Follows from Anderson and van Wincoop (2003) which in turn follows from Anderson (1979).

- Expenditure = Receipts in economy j

$$\begin{aligned} Y_j &= P_j C_j = \sum_i p_i \delta_{ij} c_{ij} \\ &= p_j S_j = p_j \sum_i c_{ji} \end{aligned}$$

- Supply: endowment economy i.e. S_i does not change when implementing policy experiment.

- Consumers in country j has CES preferences, with elasticity of substitution between varieties σ, and maximise utility to determine demand function for i's goods, c_{ij}

$$U_j = C_j = \left[\sum_i c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

$$\begin{aligned} 0 &= \frac{\partial}{\partial c_{ij}} \left[\left[\sum_i c_{ij}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} + \lambda_j \left(Y_j - \sum_i p_i \delta_{ij} c_{ij}\right)\right] \\ &= C_j^{\frac{1}{\sigma}} c_{ij}^{-\frac{1}{\sigma}} - \lambda_j \delta_{ij} p_i \\ \text{i.e. } c_{ij} &= (\lambda_j \delta_{ij} p_i)^{-\sigma} C_j \\ \text{i.e. } \delta_{ij} p_i &= \frac{1}{\lambda_j} \left(\frac{c_{ij}}{C_j}\right)^{-\frac{1}{\sigma}} \end{aligned}$$

- Utility maximisation also gives us the price level in j

$$
\begin{aligned}
Y_j &= P_j C_j = \sum_i p_i \delta_{ij} c_{ij} \\
&= C_j \lambda_j^{-\sigma} \sum_i (\delta_{ij} p_i)^{1-\sigma} \\
\text{i.e. } P_j &= \lambda_j^{-\sigma} \sum_i (\delta_{ij} p_i)^{1-\sigma}
\end{aligned}
$$

$$
\begin{aligned}
Y_j &= P_j C_j = P_j \left[\sum_i c_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\
&= P_j \left[\sum_i \left((\lambda_j \delta_{ij} p_i)^{-\sigma} C_j \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\
&= P_j C_j \lambda_j^{-\sigma} \left[\sum_i (\delta_{ij} p_i)^{1-\sigma} \right]^{\frac{\sigma}{\sigma-1}} \\
\text{i.e. } \lambda_j^{\sigma} &= \left[\sum_i (\delta_{ij} p_i)^{1-\sigma} \right]^{\frac{\sigma}{\sigma-1}}
\end{aligned}
$$

$$
\begin{aligned}
P_j &= \left[\sum_i (\delta_{ij} p_i)^{1-\sigma} \right]^{-\frac{\sigma}{\sigma-1}} \sum_i (\delta_{ij} p_i)^{1-\sigma} \\
&= \left[\sum_i (\delta_{ij} p_i)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}
\end{aligned}
$$

$$
P_j = \frac{1}{\lambda_j}
$$

- Nominal expenditure of economy j in economy i

$$
\begin{aligned}
X_{ij} &\equiv p_i \delta_{ij} c_{ij} \\
&= \left(P_j \left(\frac{c_{ij}}{C_j} \right)^{-\frac{1}{\sigma}} \right) c_{ij} \\
&= P_j c_{ij}^{\frac{\sigma-1}{\sigma}} \left(\frac{Y_j}{P_j} \right)^{\frac{1}{\sigma}}
\end{aligned}
$$

- Deriving gravity equation

$$
\begin{aligned}
Y_i &= \sum_k X_{ik} = \sum_k p_i \delta_{ik} \left(\frac{1}{P_k} \delta_{ik} p_i \right)^{-\sigma} C_k \\
&= p_i^{1-\sigma} \sum_k \delta_{ik}^{1-\sigma} P_k^{\sigma-1} Y_k \\
\text{i.e. } p_i^{1-\sigma} &= \frac{Y_i}{\sum_k \delta_{ik}^{1-\sigma} P_k^{\sigma-1} Y_k}
\end{aligned}
$$

$$
\begin{aligned}
X_{ij} &= p_i \delta_{ij} \left(\lambda_j \delta_{ij} p_i\right)^{-\sigma} C_j \\
&= p_i^{1-\sigma} \delta_{ij}^{1-\sigma} P_j^{\sigma-1} Y_j \\
&= \delta_{ij}^{1-\sigma} P_j^{\sigma-1} Y_j \frac{Y_i}{\sum_k \delta_{ik}^{1-\sigma} P_k^{\sigma-1} Y_k} \\
&= \delta_{ij}^{1-\sigma} P_j^{\sigma-1} Y_j \frac{Y_i}{\sum_k \delta_{ik}^{1-\sigma} P_k^{\sigma-1} Y_k} \\
&= \frac{Y_i Y_j}{D_i} \left(\frac{P_i}{P_j} \delta_{ij}\right)^{1-\sigma}
\end{aligned}
$$

where

$$
D_i = P_i \sum_k \left(\frac{P_i}{P_k}\right)^{-\sigma} \delta_{ik}^{1-\sigma} \left(\frac{Y_k}{P_k}\right)
$$

i.e. the gravity equation can be written

$$
\ln X_{ij} = \ln Y_i + \ln Y_j - \ln D_i + (1-\sigma) \ln \frac{P_i}{P_j} + (1-\sigma) \ln \delta_{ij}
$$

and the trade elasticity, the elasticity of trade flows between i and j with respect to variable trade costs, $\epsilon = 1 - \sigma$.

- Output price in country 1 is assumed to be normalised to 1, i.e. $p_1 = 1$. Output prices are related to price indices by:

$$
P_j = \left[\sum_i \left(\delta_{ij} p_i\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}
$$

$$
\begin{aligned}
X_{ij} &= X_{ji} \ \& \ \delta_{ij} = \delta_{ji} \\
\frac{Y_i Y_j}{D_i} \left(\frac{P_i}{P_j} \delta_{ij}\right)^{1-\sigma} &= \frac{Y_j Y_i}{D_j} \left(\frac{P_j}{P_i} \delta_{ji}\right)^{1-\sigma} \\
\frac{P_j}{P_i} &= \left(\frac{D_j}{D_i}\right)^{\frac{1}{2(1-\sigma)}}
\end{aligned}
$$

$$
\begin{aligned}
\delta_{ii} &= 1 \\
X_{ii} &= \frac{Y_i Y_i}{D_i} \left(\frac{P_i}{P_i} \delta_{ii}\right)^{1-\sigma} = \frac{Y_{ii}^2}{D_i}
\end{aligned}
$$

So

$$
\begin{aligned}
X_{ij} &= \frac{Y_i Y_j}{D_i} \left(\left(\frac{D_j}{D_i}\right)^{-\frac{1}{2(1-\sigma)}} \delta_{ij}\right)^{1-\sigma} \\
&= Y_i Y_j D_i^{-\frac{1}{2}} D_j^{-\frac{1}{2}} \delta_{ij}^{1-\sigma} \\
\text{i.e. } \delta_{ij} &= \left(\frac{X_{ij} \left(D_i D_j\right)^{\frac{1}{2}}}{Y_i Y_j}\right)^{\frac{1}{1-\sigma}} \\
&= \left(\frac{X_{ij}^2}{X_{ii} X_{jj}}\right)^{\frac{1}{2(1-\sigma)}}
\end{aligned}
$$

and

$$P_j^{1-\sigma} = P_k^{1-\sigma}\left(\frac{D_j}{D_k}\right)^{\frac{1}{2}} = \sum_i (\delta_{ij}p_i)^{1-\sigma}$$

Since data, $\{Y_i, X_{ij}\}$, gives D_i & hence δ_{ij}, this is a system of N linear equations in N unknowns, $\{P_1^{1-\sigma}, p_2^{1-\sigma}, ..., p_N^{1-\sigma}\}$

- Example with 3 countries

  - Calibration: data & parameters

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

Equations:

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

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

$$p_1 = 1 \text{ (normalisation)}$$

$$\begin{aligned}
-1 &= \delta_{12}^{1-\sigma}p_2^{1-\sigma} + \delta_{13}^{1-\sigma}p_3^{1-\sigma} - P_1^{1-\sigma} \\
-\delta_{12}^{1-\sigma} &= p_2^{1-\sigma} + \delta_{23}^{1-\sigma}p_3^{1-\sigma} - \left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} P_1^{1-\sigma} \\
-\delta_{13}^{1-\sigma} &= \delta_{23}^{1-\sigma}p_2^{1-\sigma} + p_3^{1-\sigma} - \left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} P_1^{1-\sigma}
\end{aligned}$$

i.e.

$$\begin{bmatrix} p_2^{1-\sigma} \\ p_3^{1-\sigma} \\ P_1^{1-\sigma} \end{bmatrix} = \begin{bmatrix} \delta_{12}^{1-\sigma} & \delta_{13}^{1-\sigma} & -1 \\ 1 & \delta_{23}^{1-\sigma} & -\left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} \\ \delta_{23}^{1-\sigma} & 1 & -\left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} \end{bmatrix}^{-1} \begin{bmatrix} -1 \\ -\delta_{12}^{1-\sigma} \\ -\delta_{13}^{1-\sigma} \end{bmatrix}$$

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

$$\begin{aligned} S_1 &= Y_1 \\ S_2 &= \frac{Y_2}{p_2} \\ S_3 &= \frac{Y_3}{p_3} \end{aligned}$$

- 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

$$\{p_2, p_3, P_1, P_2, P_3, D_1, D_2, D_3\}$$

8 Equations

$$\begin{aligned} P_1^{1-\sigma} &= 1 + (\delta_{12}p_2)^{1-\sigma} + (\delta_{13}p_3)^{1-\sigma} \\ P_1^{1-\sigma}\left(\frac{D_2}{D_1}\right)^{\frac{1}{2}} &= \delta_{12}^{1-\sigma} + p_2^{1-\sigma} + (\delta_{23}p_3)^{1-\sigma} \\ P_1^{1-\sigma}\left(\frac{D_3}{D_1}\right)^{\frac{1}{2}} &= \delta_{13}^{1-\sigma} + (\delta_{23}p_2)^{1-\sigma} + p_3^{1-\sigma} \end{aligned}$$

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

$$
\begin{aligned}
D_1 &= P_1\left[\left(\frac{S_1}{P_1}\right)+\left(\frac{P_1}{P_2}\right)^{-\sigma}\delta_{12}^{1-\sigma}\left(\frac{p_2S_2}{P_2}\right)+\left(\frac{P_1}{P_3}\right)^{-\sigma}\delta_{13}^{1-\sigma}\left(\frac{p_3S_3}{P_3}\right)\right]\\
D_2 &= P_2\left[\left(\frac{P_2}{P_1}\right)^{-\sigma}\delta_{12}^{1-\sigma}\left(\frac{S_1}{P_1}\right)+\left(\frac{p_2S_2}{P_2}\right)+\left(\frac{P_2}{P_3}\right)^{-\sigma}\delta_{23}^{1-\sigma}\left(\frac{p_3S_3}{P_3}\right)\right]\\
D_3 &= P_3\left[\left(\frac{P_3}{P_1}\right)^{-\sigma}\delta_{13}^{1-\sigma}\left(\frac{S_1}{P_1}\right)+\left(\frac{P_3}{P_2}\right)^{-\sigma}\delta_{23}^{1-\sigma}\left(\frac{p_2S_2}{P_2}\right)+\left(\frac{p_3S_3}{P_3}\right)\right]
\end{aligned}
$$

Then derive quantities of interest

$$
\begin{aligned}
Y_1 &= S_1\\
Y_2 &= p_2S_2\\
Y_3 &= p_3S_3\\
X_{11} &= \frac{Y_1^2}{D_1}\\
X_{22} &= \frac{Y_2^2}{D_2}\\
X_{33} &= \frac{Y_3^2}{D_3}\\
X_{12} &= Y_1Y_2\left(D_1D_2\right)^{-1/2}\delta_{12}^{1-\sigma}\\
X_{13} &= Y_1Y_3\left(D_1D_3\right)^{-1/2}\delta_{13}^{1-\sigma}\\
X_{23} &= Y_2Y_3\left(D_2D_3\right)^{-1/2}\delta_{23}^{1-\sigma}
\end{aligned}
$$

- Welfare impact:

$$
\left(\frac{Y_i'/P_i'}{Y_i/P_i}\right)-1
$$

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

F. Modifying the Minnesotan Friction with Canada for Services Trade

We use international trade data from the OECD that includes both goods and services. We assign this to US states based on their share of goods trade. Therefore, whilst our estimates of X_{Min_Can} and X_{rUSA_Can} may not be correct, there is no systematic error in these estimates since $X_{Min\_Can} + X_{rUSA\_Can} = X_{USA\_Can}$, and X_{USA_Can} is correct. Likewise, X_{Min_RoW} and X_{rUSA_RoW} are unbiased since $X_{Min\_RoW} + X_{rUSA\_RoW} = X_{USA\_RoW}$, and X_{USA_RoW} is correct.

However, the counterfactual that we are using for Quebec is Minnesota's measured friction with Canada. This is given by:

$$
\delta_{Min\_Can} = \left(\frac{X_{Min\_Can}^2}{X_{Min\_Min}X_{Can\_Can}}\right)^{\frac{1}{2\epsilon}}
$$

and, if trade in services is more home biased than trade in goods, then our our measure of X_{Min_Min} will be wrong (though X_{Can_Can} is fine).

We can produce a "corrected" counterfactual trade friction by imputing the Canadian result that HRI frictions are on average 15% lower if internal goods and services data is used rather than goods only data, by solving a system with 3 unknowns, X_{Min_Min}, X_{Min_rUSA}, & X_{rUSA_rUSA}, and 3 equations:

$$\begin{aligned} X_{Min\_Min} + X_{Min\_rUSA} + X_{Min\_RoW} &= Y_{Min} \\ X_{rUSA\_rUSA} + X_{Min\_rUSA} + X_{rUSA\_RoW} &= Y_{rUSA} \\ 2\ln X_{Min\_rUSA} - \ln X_{Min\_Min} - \ln X_{rUSA\_rUSA} &= 2\epsilon\left[\ln \delta_{Min\_rUSA} - 15\%\right] \end{aligned}$$

where δ_{Min_rUSA} is the measured HRI trade friction between Minnesota and the rest of the USA based on the goods-only attribution of trade flows.

Solving this system allows us to calculate a trade friction between Minnesota and Canada that is consistent with a goods & services attribution of USA trade data. The impact of this adjustment, for $\epsilon = -3.5$, is to lower the Minnesota-Canada friction from 2.47 without this adjustment, to 2.27 with this adjustment.

G. Quality of Counterfactuals

We can analyse the validity of the counterfactuals by comparing the counterfactual HRI with an *adjusted counterfactual HRI*, which makes it appropriate, in terms of size and physical distance, for the pair of economies that we are imputing it to, using the regression coefficients from Table 1. That is, we calculate the "Adjusted Counterfactual" HRI as the counterfactual HRI, but as if the Counterfactual-Whole Country pair had the same physical distance and size as the Region-Rest of Country pair[25].

We define:

$$\begin{aligned} \delta_{jR}^{adj} &= \exp\left(\ln \delta_{jR} + \alpha_1\left(d_{ir} - d_{jR}\right) + \alpha_3\left(\ln Y_i Y_r - \ln Y_j Y_R\right)\right) \\ \delta_{ir}^{ave} &= \exp\left(\ln \delta_{ir} + 49\%\right) \end{aligned}$$

where d_{ab} is the distance between a and b in km, and α_1 and α_3 are the coefficients on distance and size

[25]The adjusted counterfactual could also be adjusted for language. However, we believe that it would be problematic to do this. In the cross country dataset that we use, a pair is deemed to have a common language if they share an official language, so Canada has a common language with the USA and with France, but Portugal does not have a common language with Spain. Regional pairs are deemed always to have a common language (so the assumption is that sufficient English is spoken in Quebec for it to share a common language with Canada, and despite Catalonia and the Basque Country both having local languages, they are deemed to have a common language with the rest of Spain. This is a reasonable coding of the data, but strictly following this coding, we would claim that part of the difference between the Portuguese and the Catalonian or Basque frictions was a language effect, whilst language did not contribute at all to the difference between Quebec and Minnesota. We believe that this reading of the Quebec-Minnesota difference is more correct than an interpretation of language frictions in the Catalonia/Basque-Portugal difference. This is because the business community and professional classes in Quebec can speak English, and the business community and professional classes in Portugal can speak Spanish. Designating both cases as positively having a common language designation is therefore reasonable. Modifying one data point in the cross country dataset may not be appropriate - either investigate the data closely in each case or algorithmically code; but sense should be applied when conducting four detailed examples. Note that the purpose of this exercise is to estimate the value of integration directly induced by political integration. It is of course the case that political integration has indirect effects like language homogenization, and perhaps Catalonia, the Basque Country, and Quebec all have a high propensity to cease to have a common language with the rest of Spain and Canada respectively if there were to be no political integration in future. In Catalonia, for instance, all education from pre-school to university is given only and exclusively in Catalan, irrespectively of parental language. Moreover there are many voices of the pro-independent movement advocating for Catalan being the solely official language of an independent Catalonia. In the Basque country is not 100% of the education, but is the large majority in spite of the Basque language being largely minoritarian only one generation ago.In any case, all this is a matter of conjecture (for example it might have been expected that Ireland, upon independence in 1922, would make strong moves away from sharing a common language with the UK and towards being a Gaelic speaking country, but this has not happened) and is in any case not the issue we seek to investigate or quantify.

from Table 1.

Then:

	Trade Frictions				Welfare Impact		
	δ_{ir}	δ_{jR}	δ_{jR}^{adj}	δ_{ir}^{ave}	δ_{jR}	δ_{jR}^{adj}	δ_{ir}^{ave}
Scotland (Ireland)	1.53	1.81	1.85	2.51	-6.8%	-7.3%	-12.5%
Catalonia (Portugal)	1.42	2.34	2.35	2.33	-9.9%	-10.0%	-9.9%
Basque C. (Portugal)	1.53	2.34	2.51	2.51	-13.2%	-14.0%	-14.0%
Quebec (Minnesota)	1.53	2.27	2.26	2.50	-6.5%	-6.5%	-7.2%

Table 6: Imposing HRIs on regions, with trade elasticity $= -3.5$

As can be seen, adjusting for size and physical distance does not have a large impact (the counterfactuals are well matched, with the possible exception of Portugal for the Basque Country).

H. More Results Tables

	Measured HRI of Region	Measured HRI of Counterfactual	Welfare Impact
Scotland (Ireland)	1.71	2.11	-8.3%
Catalonia (Portugal)	1.55	2.89	-12.2%
Basque C. (Portugal)	1.70	2.89	-16.1%
Quebec (Minnesota)	1.70	2.79	-8.0%

Table 7: Equivalent of Table 3 but with trade elasticity, $\epsilon = -2.8$

	Measured HRI of Region	Measured HRI of Counterfactual	Welfare Impact
Scotland (Ireland)	1.33	1.49	-4.7%
Catalonia (Portugal)	1.26	1.77	-6.9%
Basque C. (Portugal)	1.33	1.77	-9.2%
Quebec (Minnesota)	1.33	1.74	-4.5%

Table 8: Equivalent of Table 3 but with trade elasticity, $\epsilon = -5.2$