Measuring the Width of National Borders

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1. Introduction

This paper deals with three issues that are central to the combined use of intranational and international data to estimate the economic consequences of national borders. The first issue concerns the measurement of trading distances for transactions that take place within a country or region. This issue dose not arise when comparisons are made between sub-national units within national economies, since in that case common distance measures are available for both domestic and international linkages. The path-breaking papers by McCallum (1995) comparing trade flows among Canadian provinces with those between provinces and U.S. states, and by Engel and Rogers (1996) on the covariability of prices between domestic and cross-border city pairs in Canada and the United States thus did not face this problem. However, subsequent authors estimating national border effects for countries without data for trade among sub-national units,[2] or comparing trade densities within and among sub-national states or provinces[3] have not been so lucky. They have had to find some way of measuring internal trading distances, being well aware that their estimates of border effects were only as good as their estimates of internal trading distances, since any error in the mean internal distance will be reflected by a proportionate change in the same direction in the estimated size of the border effect. I argue here that the methods previously used are inadequate, and present a preferred alternative method.

The second issue relates to the use of coefficients from an estimated gravity relation to express the border effect in terms of an equivalent distance. I shall argue that the method originally used by Engel

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[2] These include Wei (1996) and Helliwell (1997, 1998) for OECD countries, Helliwell (1998) for a global sample of countries, and Nitsch (1997) for EU countries.

[3] Wolf (1997) compares intra-state and interstate trade intensities, while Helliwell (1998, chapter 2) does the same for Canadian provinces.

and Rogers (1996), and since used by Parsley and Wei (1999) and others, has serious problems. An alternative technique will be proposed that avoids these problems and provides a natural interpretation of the size of the border effect.

Finally, I shall emphasize the need to ensure that the border and distance effects are independently estimated, and suggest a means of ensuring that this is indeed the case. The following three sections deal in turn with each of these issues.

2. The Computation of Average Internal Trade Distances

Wei (1996) approximated internal trade distance by one-quarter of the distance from the capital city to the capital city of the nearest neighbouring country. This approach has also been used by Helliwell (1998) and others, but has been criticized on the grounds that the potential distances for domestic trade should depend only on the geography of a country, and not on that of its neighbour[4].

One simple but attractive approach to the modelling of potential internal trade distances is to assume a specific geographic shape and calculate the mean distances among equally spaced points within the country. A natural generalization of this is to make the economy comprise urban areas set within more sparsely populated rural areas, with economic activity equally spaced within each conurbation (but with densities that vary from city to city) and residual activity, mainly based on agriculture and natural resources, spread more evenly across the remaining space. Adopting the first procedure gives much higher estimates of internal trade distances, and hence of national border effects, than does the assumption used earlier by Wei and others. Application of the urban model requires much more specific information about the spatial distribution of population and GDP within specific countries.

In this section, one method for implementing this strategy is sketched out, based on the procedures developed more fully, and applied to Canadian provinces, in Helliwell and Verdier (1999). The average internal trade distance for each country or region is a weighted average of intra-city distances, inter-city distances, the average distance between cities and rural areas, and the average distance from one point to another within a rural area. To be consistent with the theory of the gravity models in which the distance

[4] Volker Nitsch (1998).

estimates are to be used, the weights should be proportional to the measures of mass used in the gravity equation. This is usually GDP, although some gravity models have made separate use of its two components: population and GDP per capita. In international studies, which typically involve fairly large differences in per capita incomes, the two components have been found to have different effects, with the elasticity of trade with respect to per capita income being higher than with respect to population. For most countries. census data provide a solid basis for the geographic distribution of population, while there are no comparable data for the spatial distribution of GDP.

2.1 Intra-city distances

We take each city to be represented by a square, the dimensions of which are taken to be the square root of the physical surface area of the city. To compute the average distance between transacting parties, we assume that they are uniformly distributed over the surface.

Let r be the half of the side of the square defined above. We evenly distribute points across the square at each $0.01r$ of the square, starting from a corner. To illustrate, suppose we have two points E and F with coordinates (a, b) and (x, y) respectively as in the figure below.

The distance between E and F is then computed as follows:

Distances between any two points in the square are thus computed and the average internal trade distance for city i (d_i) is taken to be the mean of these distances.

Once the individual intra-city distances have been computed, the average intra-city trade distance d_{intra} for each region or country is computed as follows:

where d_i is the internal trade distance for city i, and p_i is the population of city i. Each city distance is weighted by the square of its population to account for trade within the urban area.

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The inter-city distances d_{ij} are used to computed the average inter-city trade distance d_{inter} for each region or country as follows:

where N is the total number of urban areas. Each inter-city distance is weighted by the product of the populations of the city pair to account for trade between cities, because trade in the gravity model is proportional to the product of the economic masses of the centres between which trade takes place.

2.3 Distances to rural areas

Two types of distances are left to be computed: the average distance from a city to rural areas, and the average distance from one point to another in a rural area. The average distance from one rural point to another in the same rural area is computed in the same way as the average intra-city distance, with the national surface area replacing the city surface area. The average distance from a city to the rural area in which it is located is computed as a special case of the rural-rural calculation, since it is not the average of all pairwise distances in the space, but instead is the average distance from one selected point to each other point in the rural area.

2.4 Average internal distances

[illegible]

The following weights are used:

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

[illegible]

[5] If the country is circular, the average distance between equally spaced points is .75 times the square root of the area, while if the country is a square the average distance is approximately 1.08 times the square root of the area.

	Wei	***sq rt Area***	***0.26*sq rt Area***	***H&V 1999***
Ontario	77.	991.	257.7	215.6
Quebec	77.	1218.	316.7	211.3
BC	104.8	959.	249.3	182.1
Alberta	103.5	800.	208.0	218.4
Saskatchewan	83.3	795.	206.7	231.8
Manitoba	83.3	792.	205.9	151.5
New Brunswick	32.	273.	71.0	136.9
Nova Scotia	28.3	241.	62.7	136.9
Newfoundland	125.5	633.	164.6	243.3
PEI	28.3	71.	19.8	40.9

[6] Measured across the ten provinces, the correlation between the squared area and the H&V measures is 0.76.

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[7] In McCallum (1995) anh Helliwell (1998) the border effect was captured by a variable which took the value 1.0 for all observations relating to interprovincial trade. It was thus equal to 1.0-BORDER, and obtained a positive coefficient in explaining trade flows. The BORDER and DIST variables used in this paper are both expected to take negative coefficients in equations explaining trade flows, and positive coefficients in studies of price co-variability.

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To solve both problems, it is only necessary to calculate what the distance effect would be with and without taking account of the intervening border. To compute the distance effect of the border, we need to calculate what increase in distance, starting from the average distance separating the international pairs, would exactly offset the effects of the border. If we let db be the distance equivalent of the border, and dbar be the average distance between international pairs, db is calculated from the following equality:

$\alpha_{H}\ln(dbar+db)=\alpha_{H}\ln(dbar)+\alpha_{\smile\smile}$

so that

$\ln(dbar+db)=\ln dbar+\alpha_{\smile\smile}/\alpha_{H}$

and

$db=\exp(\ln dbar+\alpha_{\smile\smile}/\alpha_{H})-dbar$

[8] In his discussion of the Parsley and Wei paper at the Gerzensee conference.

This corrected procedure makes an enormous difference to the estimated border widths. Using 1346 miles as the average distance between the selected U.S-Canada city pairs (Engel and Rogers, 1996, 1116), the Engel and Rogers estimate of 75,000 miles becomes 101 million miles, while their 1780 miles becomes 2.4 million miles. Using the distance of 6891 miles between Osaka and Houston, the Parsley and Wei estimate of 13 billion miles becomes 85 trillion miles.

How do the alternative measures of border width fare when applied to trade flows? Using the coefficients of McCallum (1995), and the U.S.-Canada distances of Engel and Rogers, the width of the Canada-U.S. border is 8.8 miles using the Engel and Rogers procedure and 10,500 miles using the procedure suggested above.

The huge estimates for border widths in the price variability studies, relative to those from the studies of merchandise trade, are a consequence of the combination of a relatively small distance effect with a large border coefficient. The implication is that price variability, at least at the short-term frequencies studied in these two papers, is subject to little or no international arbitrage. This result is amplified by the large short-term variability of nominal exchange rates, which dwarfs the variability of domestic prices of goods and services, and hence reduces sharply the extent of international covariability of two country's domestic prices once they are expressed in a common currency. This issue is of greatest importance at short frequencies, such as the monthly and two-monthly price differences studied by Engel and Rogers, since exchange rates are much more variable than domestic prices at such short frequencies.

4. Interaction of Distance and Border Effects

The above calculations, whether using the original Engel and Rogers procedure or that suggested in this paper, are based on a comparison of the coefficients on the distance and border variables. For these calculations to be valid, it is necessary that the distance coefficient applies equally to internal and cross-border distances. Since this is easily checked, to do so should be an integral part of any attempt to estimate the width of national borders. One way of performing the test is to estimate separate distance coefficients for intra-national and inter-national linkages, and then test for equality.

To do this test for the Engel and Rogers (1996) price co-variability data for U.S. and Canadian cities, three separate distance coefficients are required, one each for co-variability among U.S. cities, among Canadian cities, and between U.S. and Canadian cities. The U.S. and Canadian internal coefficients are insignificantly different from one another, but are both significantly different from zero. The distance coefficient for the cross-border city pairs is significantly different from the internal distance coefficients, and insignificantly different from zero. This has the effect of making the width of the border infinitely great, with the natural inference being that for short-term international price variability, there is no effective international arbitrage. This result is quite consistent with the large and sustained departures from purchasing power parity documented by many studies.

For the analysis of trade flows, the results are quite different. As reported in Helliwell (1998), estimation of separate distance coefficients for interprovincial and province-state trade flows shows them both to be significantly different from zero and insignificantly different from each other. Thus the 10,500 mile border width calculated from the McCallum coefficients is on secure ground. Future studies of border effects should make these tests as a matter of course.

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