New Border Effects Evidence

From Canada-U.S. Regional Trade Model

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Abstract

This paper uses the theory of trade in differentiated goods to construct a theoretically based regional model of trade in North America and estimates border effects arising from it. Earlier critiques of the empirical gravity equations – Anderson (1979) and others – indicate that a gravity equation with a theoretical foundation is essential for obtaining legitimate results. Accordingly, our specification contains the key price variables implied by theory, as well as the effects of tariffs and the role of governments; we also introduce the use of time series techniques to the field by estimating a 1988-2003 data panel. We thus take into account both theory and econometric practice to produce estimates superior to prior research. These estimates paint a picture significantly different from that of the earlier studies by McCallum (1995), Helliwell (1998) and others.

There are four principal conclusions from this paper: a) border effects between Canada and the U.S. are much lower than suggested by previous research; b) the decrease in border effects with time established in the literature is largely due to the omission of tariffs as an explanatory variable; including tariffs and making use of time series techniques shows that Canada - U.S. border effects net of these factors have actually risen with time; c) national and regional governments in North America are one of the

explanatory factors for border effects, and d) the overall border effect is found to be largely import-driven, meaning that Canadian provinces are much more averse to importing from the U.S. than to exporting there.

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1 Introduction

Over the past two decades, two major free-trade agreements have been implemented to enhance the economic integration of North America. Yet the same period of time was marked by the rise of the border effects literature that has questioned the degree of this integration – first in North America and then elsewhere. This literature, reviewed in earlier chapters, reaches a general conclusion that the differences among nations continue to affect substantially the pattern of trade (a more accurate rendering of McCallum's (1995) message "national borders matter"). Significant differences are invariably found when international trade intensity is compared with the intensity of internal trade; the magnitude of these differences ranges between 2 and 50, as shown in the meta-analysis of the preceding chapter. These differences may be interpreted as representative of the unexplained factors that cause the merchandise trade across an international border to deviate from the pattern predicted by the gravity equation. Although the gravity equation is one of the most frequently and successfully used tools of international economics, there is no agreement on what causes the border effects and what specification is the most appropriate to estimate them. This study introduces a model of trade between the regions that answers some of the unsolved questions in this area and also challenges some of the old answers. The purpose of this paper is, first, to develop a theory-driven model of regional trade between Canada and the U.S.; second, to estimate the various types of border effects that arise from it; and third, to employ time-series and econometric techniques to determine the time path of the border effect in a sixteen-year setting.

Merchandise trade in the model is assumed to be driven by differences in varieties of produced goods, first explored in Dixit & Stiglitz (1977) and Krugman (1980). This model is modified in three ways, namely: by introducing the geographical origin of goods, as in Head & Mayer (2000), by making the model regional rather than national, and by adding important (heretofore usually omitted) explanatory variables to the model. The combination of the unique Canadian data on regional trade flows, the geographical situation of the two trading partners and their many institutional similarities make the Canada-U.S. border the most promising test of this model.

We now have access to sixteen years of data (1988-2003) on Canada-U.S. merchandise trade flows which are first analyzed cross-sectionally for compatibility with earlier results, and then with time series techniques in a panel setting. The time series panel allows us to control for the effect of additional variables (such as tariffs) that can not be incorporated in a single-year cross-sectional estimation. The results of this exercise suggest that a theory-driven model produces a fairly narrow band of estimates for border effects between Canada and U.S. over this period. These are significantly lower than suggested by most previous research - between 4 and 7 cross-sectionally for all years, and between 2 and 6 in a panel setting. The model estimates are very robust to the choices of estimation techniques, and all the explanatory variables in the final version of the regression model are highly significant in explaining regional trade.

The results obtained with the use of time series panels are of particular interest. A common finding in the literature is the decline of the border effects through time; in particular, it was claimed that the Canada-U.S. border effects have declined significantly after 1988. This result was thought to be due to the phase-out of tariffs following the adoption of the Canada-U.S. free trade agreement in 1989. We show that this observed decline in border effects was largely explained by tariff reductions, confirming the hypothesis of the literature. Furthermore, the influence of even a small tariff on the border effect estimates is found to be very large - a 3.5% average tariff level in 1988 approximately triples the border effect estimate in that year. However, as tariffs are usually a known factor, and inflate border effects greatly if not explicitly modeled, we see no justification for leaving them out of the empirical specification as was done in previous studies. Our border effects estimates are thus “net” of tariffs, and represent, by definition, a combination of unexplained or omitted factors. It is in this sense that we discuss our results throughout this chapter.

When tariffs are modeled and included as explanatory variables along with fixed time effects and time-border interaction terms, border effects are actually shown to have persistently increased during the 1988-2003 time period: from 2.2 in 1988 to 5.5 in 2003. Overall, this result may be viewed as the second part of the warning, the first having been delivered by McCallum in 1995: not only do border effects exist in a globalising world – but they may also be increasing. We show that this increase has passed unnoticed by the earlier studies due to the combination of exclusion of tariffs, misspecification and omitted variables in the gravity equations used for estimation. Also, previous studies were not done in a panel context. We believe that a compensating rise in non-tariff barriers, changes in preferences underlying the patterns of trade and the increased security concerns in the United States may all have contributed to the observed increase in border effects over the 1988-2003 period.

Further analysis by Canadian region shows that the model yields results broadly consistent with previous research, notably Anderson & Smith (1999) and Helliwell (1996, 1998). A significant difference from these studies is discovered when estimating the border effects by direction of trade: all Canadian provinces and the country as a whole show a strong border effect for imports, and much lower (for some provinces even insignificant or positive) border effects for exports. This means that while Canadian provinces are nearly as willing to export to the U.S. as they are to other Canadian provinces, they are relatively unwilling to import goods from the U.S., and likely make up the shortfall by importing from the rest of the world. In particular, an ongoing increase between 1997 and 2003 in import border effects vs. the U.S. (from 11 to 17) may be due to the rising importance of the low-labour-cost countries as a source for Canadian imports. This implies a triangular pattern of trade that can bias the border effect estimates that are produced across a single border using only trade data for the two countries in question. The ongoing changes in trading patterns with other suppliers should be taken into account – an important observation for further research.

Lastly, the effect of the explicit introduction of the government motivated by its supposedly discriminatory policies in favour of the domestic suppliers has been significant in the expected direction. This justifies our conjecture that "buy national" policies give a relative boost to intranational trade vs. international trade and that the involvement of the government in the economy is one of the explanatory factors for the border effect.

The remainder of this paper is organized as follows: in section 2, we present a short review of the directly relevant research and its contributions, with particular stress on the Canada-U.S. studies and methodologies. In section 3, we develop a theoretical regional model of trade in differentiated goods, incorporating the theoretical critique of Anderson (1979), Bergstrand (1985), Deardorff (1998) and Anderson and van Wincoop

(2001), and derive a specification that can be estimated by linear regression techniques. Although in many studies the data section can be relegated to an appendix, for a border effect study the data sources often play a crucial role. Therefore in section 4, we discuss the data requirements of the model and our solutions to the data issues that arise. Section 5 presents the estimation results obtained with several estimation techniques and the decomposition of border effect by region and direction of trade. Section 6 concludes and draws implications for further research.

2 Research into Border Effects as a Measure of Integration

The empirical demonstration of the continued relevance of the international borders, even those believed to be relatively innocuous such as the Canada-U.S. border, was first performed by McCallum (1995). His seminal paper on the Canada-U.S. trade used the newly available data source unique to Canada: as a highly decentralized federation, Canada was the only country in the world to collect and publish data on its interregional merchandise trade flows. Combining this data with international trade (also disaggregated by region) allowed the border effect to be estimated through the gravity model by comparing the international trade of Canada to its intranational trade after correcting for economic size and distance between the regions.

Before the discussion of McCallum's results, a few notes on the gravity model are necessary. First and foremost, it expresses an empirical regularity well known to trade economists, stating that imports of country i from country j (or, more generally, the trade flows between the two) are directly proportional to the GDPs of these countries and inversely proportional to the distance between them. Taking logarithms of both sides of this statement results in a standard log-linear form of the gravity equation, which is occasionally augmented by several other variables thought to be of empirical importance. Its empirical success in explaining the majority of trade flows and its robustness in doing so for various places and periods have led to efforts to legitimize its success by providing a solid theoretical foundation for the equation. At present, the gravity equation has been derived both from models of trade in differentiated goods and the Heckscher-Ohlin factor endowments model. Recent research into border effects emphasizes that theory must be taken seriously, and any gravity equation used should be derived from theory. Appendix A discusses the gravity equation and its derivation in more detail, and points out the elements that result from a specification's theoretical origin.

Using the simple empirical gravity equation and specifying a dummy for cross-border trade, McCallum has shown that after taking size and distance into account, a Canadian province trades on average twenty-two (22) times more with another province than with a U.S. state. These findings were met with a mix of curiosity and disbelief; while the disbelief subsided as the results were confirmed by follow-up research, the curiosity has since generated dozens of publications. Wei (1996) showed the existence of border effects for the OECD countries, and Helliwell (1997, 1998) confirmed and extended McCallum's findings. Helliwell's research also linked McCallum's results to other fields. He pointed out in Helliwell (1997) that the phenomenon found by McCallum is not isolated, and that border effects essentially equivalent to McCallum's were found by Engel & Rogers (1996) in their study on price variability, by Feldstein & Horioka (1980) - for international capital markets; the author's original research in the same paper finds border effects in migration. These linkages established the place of border effects in international trade and led to the current interpretation of the border effects as a proxy for the *unexplained factors* in differences between the nations, causing the border between them to appear to diminish trade after all known and quantifiable factors are accounted for by the model.

For the purpose of this paper, there are three main threads in the current literature on border effects that are relevant: assessing the impact of border effects on welfare, using additional variables to explain the border effect, and constructing theoretical explanations for this phenomenon (preferences- or networks-based). Although the first approach has yielded some interesting results (generally, border effects are found to result in relatively small welfare effects), we consider this research question somewhat premature as well as somewhat vague. It is premature because the theoretical critique levelled at the border effect estimates finds them biased; a better specification is necessary to estimate their true size (which is the approach advocated by us). It is vague because it is not clear how borders can consistently generate welfare losses in market economies with democratic political systems.

This last point might require an explanation. The national borders created and maintained by democratic governments (research was mainly done on European and North American OECD members) can be reasonably assumed to represent the will of their populations. If these populations are presumed rational, it is not clear why welfare-reducing borders would not be dismantled by them. Hence, either the borders must create greater welfare gains in other areas or their welfare effects are not calculated correctly. The latter is a strong possibility as the border effects represent unknown factors, and the assumptions about those must necessarily be uncertain. For example, if nationalism is part of the utility function, welfare losses from trade are more than offset by welfare gains from living in a nation-state among people with shared norms and culture. This argument is not meant to introduce ad-hoc factors to invalidate existing welfare measurement models; the reasoning is that these models must necessarily be omitting variables because their premise of voluntary welfare losses by rational economic agents is at odds with the economic theory.[1]

Our approach, then, is to leave aside the welfare issue and to put the calculation of the border effects on a more solid theoretical basis by deriving the empirical model from a theoretical framework. A well-defined theoretical model will permit a more precise interpretation of the empirical results, in particular the issues of size, direction and intertemporal behaviour of border effects. Once a generally accepted methodology is developed for the measurement of border effects, it will open the way for their very useful interpretation – to assess the true degree of economic integration between the goods sectors of any two economies. The evolution of border effects through time will then serve as an indicator of the pace of this integration. It is our hope that this study may contribute to the development of such generally accepted methodology.

It remains difficult to estimate border effects for countries other than Canada because of the lack of reliable internal trade data to compare against international trade flows. Wei (1996) introduced a methodology that measures internal trade as gross

[1] On the other hand, the estimates of welfare impact of the borders can prove to have a useful interpretation. If the economic welfare losses due to the trade-decreasing features of the existing borders are more than compensated for by the positive welfare effects of their presence (such as nationalism), one could put a price on nationalism. At the moment when the borders are dispensed with, in such a manner as is currently ongoing in the European Union, their negative economic welfare effects (which can be calculated) must equal their positive welfare effects due to nationalism.

shipments in the goods sectors less merchandise exports, and internal distance as one-quarter the distance to the nearest state. This method has been criticized as producing inconsistent trading distances, and much work has been done since on improving internal trading distance estimates, for example Leamer (1997), Helliwell & Verdier (2001), Head & Mayer (2001), Nitsch (2000). In particular, Helliwell & Verdier (2001) argue in favour of measuring population-weighted internal distances that take into account intra-city, inter-city and rural population distributions; this study uses their internal distance estimates. However, there has been no corresponding advance in internal trade flows statistics for other countries, and as of now, there are few alternatives to Wei's proxy to measure internal trade in countries other than Canada. Such an alternative exists in the United States, where Hillberry (1998) pioneered the use of the Commodity Flow Survey (CFS) to produce estimates of internal trade; it is not without its problems. The issues associated with the use of the CFS data are discussed in the data section.

This variety of methods and geographical locations has produced a series of border effect estimates varying between 2.6 and 50, depending on the country and time period in question. There has been a general tendency for the Western European countries to exhibit smaller border effects that Canada-U.S., and also a tendency for the border effects to decrease over time (usually explained as the result of increasing economic integration). A considerable variety of specifications have been developed and a number of additional explanatory variables such as common language, adjacency etc. have been introduced to the gravity equation with the hope of explaining the border effect. Facing this assortment of variations, Anderson and van Wincoop (2001) delivered a strong message: only gravity equations explicitly derived from international trade theories should be used to estimate border effects; ad-hoc specifications suffer from omitted variables and model selection biases. This paper has shown that previous research has paid only lip service to trade theory, and the gravity equations commonly used did not include the crucial price variables and remoteness (or multilateral resistance) variables. Anderson and van Wincoop (2001) started two important trends in the literature: more emphasis on theory, and consideration of the welfare impact of border effects.

Most purely theoretical models in this area, however, proved to suffer from difficulties in deriving a specification that can be estimated. Anderson & van Wincoop (2001), for example, found it necessary to derive a CGE model to obtain a partially testable equation, requiring assumed values and calibration for the elasticity parameters; the complexity of that approach and an alternative to it were pointed out by Feenstra (2002). From this critique stems the importance of the contribution to the field by Head and Mayer (2000, 2001). These papers significantly simplified the derivation of a linear specification from a model of trade in differentiated goods (i.e. under monopolistic competition). After deriving the final expression of trade flows from exporter to importer from their model, they divide it through by the corresponding expression for trade flows from importer to itself (i.e. the internal trade of that importer). The resulting expression is log-linear in ratios of the main variables of the model, and the remoteness variables implied by theory (describing the distance of the importer from every other trading partner) cancel out. This result takes advantage of the property of independence from irrelevant alternatives of the CES demand function, and leads to a much simpler final specification that can be fully estimated, and depends only on the ratio of explanatory variables for the importer and exporter countries.

We follow McCallum (1995) in being curious about border effects, Anderson and van Wincoop (2001) in taking theory seriously, and Head and Mayer (2000) in making the decision to take theory seriously an easier one. Our specification is derived from the theory of trade in differentiated goods. We differ from previous research by deriving a regional (as opposed to national) model of trade, by augmenting it with additional relevant explanatory variables, and by taking advantage of the extensive Canadian regional trade flows data to construct a more detailed model of international trade in North America than has been attempted before.

3 Theoretical Model

The previous Canada-U.S. trade models treated the regions as agents, but by and large specified their trading relationship *ad hoc* in a plausible gravity setting. On the other hand, theoretical models of border effects under monopolistic competition that used the Head/Mayer simplification have been employed only in the European Union-OECD setting and so were specified at the national level. To our knowledge, they have not been used in a regional setting to explain the Canada-U.S. trade. We combine the two approaches to construct a theory-based regional model of trade in differentiated goods. Each region is treated as an independent agent, trade flows between the regions include both intra- and international trade and these are compared to the internal trade within the regions themselves. This approach permits greater insight into the trading behaviour of the regions and should lead to a more coherent specification of the gravity equation, which can address the research question about economic integration between national economies and among their constituent regions.

We start with the same general specification of preferences as Head & Mayer (2000) in their national trade model, and we extend that model to regions operating as independent entities. Let there be *K* countries, each divided into r_k regions ($k \in 1 \ldots K$) for a total of $R = \sum_k r_k$ regions which trade with each other. In all subsequent notation, we shall denote an importing region with *i* and an exporting region with *j*.

3.1 Consumers' Problem

All of the varieties of goods, denoted by *v*, are differentiated, and each variety is produced by a different firm. The varieties produced by each region are assumed to weigh equally in the utility function. The utility of the representative consumer in region *i* is a CES function. This function depends on the quantities of all varieties consumed from all the exporting regions[2] and consumer preferences *a*, and is characterized by the constant elasticity of substitution σ:

$$U_i = \left(\sum_j \sum_{v=1}^{n_j} \left(a_{ij} c_{ijv} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \qquad (1)$$

where n_j is the number of varieties produced by an exporter region *j*.

[2] These include the region *i*, and thus the varieties imported from itself.

Consumption in the region i of all the varieties of goods from region j is expressed by c_{ij}. These goods are purchased at the price p_{ij}, common for all the varieties of region j's goods imported by region i, and representing the C.I.F. price of goods delivered into region i. Thus the total expenditure of each region on imports from all regions (including itself) can be expressed as:

$$m_i = \sum_j m_{ij} = \sum_j c_{ij} p_{ij}, \qquad (2)$$

where m_i can be interpreted as total imports value (including imports from itself) and the bilateral imports value m_{ij} denotes imports from a particular region j.

Maximizing (1) subject to the budget constraint (2), we derive the following expression for the bilateral imports of region i from region j:

$$m_{ij} = \frac{a_{ij}{}^{\sigma-1} n_j p_{ij}{}^{1-\sigma}}{\sum_r a_{ir}{}^{\sigma-1} n_r p_{ir}{}^{1-\sigma}} m_i, \qquad (3)$$

where a_{ij} represents the consumer preferences of region i with respect to the goods of region j, and n_j is the number of varieties produced by region j.

Direct estimation of (3) is difficult because its logged form includes an intractable remoteness term, which depends on the values that are already in the equation and furthermore is supposed to contain information on all the possible trading partners. To obtain a specification that significantly simplifies estimation, we follow Head and Mayer

(2002) in setting $j = i$ in (3), which results in an expression for m_{ii}. Dividing the bilateral flows in (3) by these internal flows m_{ii} we obtain the expression:

$$\frac{m_{ij}}{m_{ii}} = \left(\frac{a_{ij}}{a_{ii}}\right)^{\sigma-1} \left(\frac{p_{ij}}{p_{ii}}\right)^{1-\sigma} \left(\frac{n_j}{n_i}\right) \quad (4)$$

3.2 Producers' Problem

On the production side, we assume that there are a large number of firms, each producing a differentiated variety. All firms use the same technology in which labour is the only input. Following the Dixit and Stiglitz (1977) model of monopolistic competition, the cost function of a firm in region j is assumed to contain a fixed component and a unit input coefficient, both multiplied by the wage rate. This cost function is written as follows:

$$C_j = w_j(F + cq_j), \quad (5)$$

where c is a unit input coefficient converting output produced into hours worked, F is a fixed cost (in terms of hours worked) necessary for production, and w_j is the wage rate in region j.

Profit maximization implies that marginal revenue is equal to marginal cost. Recall that σ is the implied elasticity of substitution. Thus:

$$p_j = \frac{\sigma c}{\sigma - 1} w_j, \tag{6}$$

where p_j is the factory gate price of output in region *j*, same for each variety because wage rates are equalized due to perfect labour mobility. Market equilibrium is obtained from a zero-profit condition. Setting the profit function equal to 0, using (6) and solving for quantity produced by any firm, we obtain:

$$q = \frac{F(\sigma - 1)}{c} \tag{7}$$

If the total value of production in the region is denoted as v_j, and the quantity produced by each firm is *q*, then:

$$v_j = q p_j n_j \tag{8}$$

The price p_{ij} depends on the factory gate price p_j and the barriers to trade separating the two trading regions. These barriers include transportation costs and tariffs on trade between the regions. Following previous research, we use a non-linear function of distance as a proxy for transportation costs. While transportation costs are defined for all regional pairs, the tariff barriers are different from zero only if the regions are in different countries. The effect of tariffs is also allowed to be non-linear as there is some evidence that it may change with the tariff size[3]. Thus:

$$p_{ij} = (1+T_{ij})^{\theta} d_{ij}^{\delta} p_j, \tag{9}$$

where d_{ij} is the distance between regions and T_{ij} are tariff barriers between the regions in different countries.

3.3. Deriving the Specification

We turn now to the more detailed consideration of the preferences term a in the utility function. Basic consumer preferences consist of a random term ε_{ij} and a general preference for domestic goods. This reflects the unknown source of home bias that translates into the border coefficient of the equation. Preferences are also affected by the strength of informal networks between the regions: shared norms, trust, customs and culture. Although difficult to measure, their importance has been stressed in the literature, most recently in Helliwell (2003). We propose to capture a measure of these family, cultural and social networks by defining a so-called *linguistic affinity* between regions i

[3] Theoretically, the marginal effect of a tariff may be expected to be inversely proportional to the tariff value. At low tariff levels, a trader still faces fixed costs of information and compliance with the tariff schedule. Thus, in the environment of small decreasing tariffs between Canada and the U.S. in the 1988-1998 period, even marginal tariffs could generate relatively substantial barriers to trade, and thus influence final prices non-linearly. And empirically, the large expansion in trade between Canada and the U.S. after the 1988 FTA cannot be explained by the simple removal of tariffs, which had already been low before it was signed.

and j. Sharing a linguistic tradition of a trading partner is assumed to facilitate networks and connections that form the basis of trade.

Previous literature showed the significant role of the adjacency effects. We incorporate this as an additional measure of network effects – a preferential affinity for goods from a region sharing a border with the importer. This adjacency effect presumes that sharing a border leads to sharing some of the neighbour's networks, norms and values through common historical and cultural evolution. A region is considered to share a border with itself.

Lastly, preferences are also assumed to depend on the common government. Governments usually adopt and promote "buy domestic" policies, enhancing trade between the intranational regions. As mentioned above, other unexplained effects in addition to those specified by the model are captured by the border effects dummy B. Including these terms results in the following general specification for consumer preferences:

$$a_{ij} = \exp[\varepsilon_{ij} - \beta B_{ij} - \eta ADJ_{ij} + \lambda L_{ij} + \gamma G_{ij}], \tag{10}$$

where $B_{ij} = 0$ if i and j are in the same country and 1 otherwise

$ADJ_{ij} = 0$ if a shared border exists or i = j, and 1 otherwise

$L_{ij} = \sum_{l=1}^{M} L_{il} L_{jl}$, where $l \in 1...M$ is the number of languages spoken in a region and L_i and L_j are the proportions of speakers of these languages in the region.[4]

$G_{ij} = 0$ if the regions are in different countries and $G_i * G_j$ otherwise, where G_i is the ratio of the federal government's expenditures to the total gross domestic product of that region. Exception is made when i = j; in that case G_i denotes the ratio of the total federal and provincial/state governments' expenditures in that region to its GDP. The intuition for this specification is as follows: the provincial/state government induces home bias in trade only at the intraregional level, while the federal government creates home bias both at intraregional and interregional levels[5]. Thus the internal trade of every region is subject to maximum government enhancement in a federal political system that exists both in Canada and the United States.[6]

Substituting (6), (7) and (8) into (3), taking logs and linearizing, we obtain:

$$\ln\left(\frac{m_{ij}}{m_{ii}}\right) = \ln\left(\frac{v_j}{v_i}\right) - (\sigma - 1)\delta \ln\left(\frac{d_{ij}}{d_{ii}}\right) - \sigma \ln\left(\frac{p_j}{p_i}\right) -$$

$$-(\sigma - 1)\theta \ln(1 + T_{ij}) - (\sigma - 1)\beta B_{ij} - (\sigma - 1)\eta ADJ_{ij} +$$

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[4] The expression for L_{ij} is derived as follows. Assume there are *N* individually owned firms in each region, owned by *N* consumers who speak two different languages: *n* speak language *A* only and *(N-n)* speak language *B* only. Each firm has flat production costs, is a price-taker, and its ability to make a sale is affected only by the language match between the producer and potential customer. Assume the extreme situation: a sale is only made if the languages spoken both match. Then, assuming sales are also made to oneself, the quantity of internal sales will be $n^2 + (N-n)^2$ and the quantity of external sales $n_1 n_2 + (N - n_1)(N - n_2)$, as per the formula above.

[5] Theoretically, the federal and provincial/state governments could have different propensities to induce home bias out of their spending shares. We assume these to be equal for tractability purposes.

[6] The impact of government on trade in context of border effects literature was to date considered only in Crozet and Trionfetti (2002); however a specification for estimation was not explicitly derived, and government was introduced into a Head/Mayer type model *ad hoc*. Our model derives the impact of the government directly from theory.

$$+(\sigma-1)\lambda(L_{ij}-L_{ii})+(\sigma-1)\gamma(G_{ij}-G_{ii})+e_{ij}, \qquad (11)$$

where $e_{ij}=(\sigma-1)(\varepsilon_{ij}-\varepsilon_{ii})$. Estimating this expression for bilateral flows between regions *i* and *j* produces an estimate of border effects as the coefficient on the country dummy B_{ij}.

As the specification implies, and following Anderson & Smith (1999) as well as Helliwell (1998), we estimate this equation for imports and exports separately. This procedure doubles the number of available observations as well as allows us to disaggregate border effects into import and export components. Estimates by regions can also be obtained by estimating a particular region's trade flows only.

We apply this specification to trade flows between U.S. and Canada for 1988-2003. Cross-sectional regressions cannot incorporate tariffs due to perfect collinearity with the border dummy and thus tariffs are included only in panel regressions.

4 Data

We follow McCallum (1995) and Helliwell (1996, 1997) in restricting the sample to thirty largest U.S. states, including all those which border on Canada, and ten Canadian provinces. A detailed summary of the sources and adjustments for trade data is provided below, after we first describe how all the other data were obtained.

4.1 General Data

Regional GDP data at factor cost, both in current and chained dollars, are obtained from the Bureau of Economic Analysis and CANSIM. The ratio of current and constant regional GDPs gives us our best estimate of producer price indices, which are not available by region; these indices are then adjusted with the aggregate price level for 1988 to produce comparable price series for U.S. and Canadian regions. Distances, including more accurate internal population-weighted distances as described in Helliwell and Verdier (2001), were kindly provided by the former and are the same as used in Helliwell (2003). Aggregate estimates of effective tariff rates on goods for this period have been kindly provided by Sébastien LaRochelle-Côté from his Statistics Canada publication, *Tariff Reduction and Employment in Canadian Manufacturing, 1988-1994*, June 2005. Language data is based on home language questions of the U.S. and Canadian censuses for the English, Spanish and French languages, and interpolated for intercensal periods. U.S. government expenditures by region at the federal and state level were obtained from Consolidated Federal Funds Reports (CFFR) and internal databases kindly provided by the Bureau of Economic Analysis; comparable Canadian data were obtained from CANSIM.

4.2 Canadian Interprovincial Trade Data

Data on Canadian interprovincial trade flows, first identified by McCallum as usable in a regional gravity regression, are now available for years 1988 to 2003. The quality of data is uneven throughout this period. 1988 data are available from the original source used by McCallum - the matrix of interprovincial goods trade provided in the occasional Statistics Canada publication, *Interprovincial and International Trade Flows of Goods, 1984-1988,* Input-Output Division, Technical Series #49, June 1992. 1989-1991 data was obtained by us through a special request from Input-Output Division. These data were characterized as older and less reliable by Statistics Canada than modern post-1997 estimates. It also cannot be updated or re-estimated due to change of classifications. Insofar as it remains the only source of data on interprovincial trade flows for these years, we must continue to use it; however, concerns about data quality within this "early" period require that we estimate the 1988-1991 years separately, and treat comparisons with the results for other periods carefully. Since the results in the next section show the data to be largely consistent across the whole period, we later feel justified in working with estimates for the 1988-2003 panel as a whole.

Data between 1992 and 2003 are publicly available from CANSIM (tables 386-0001 and 386-0002). Between 1992 and 1996, some of the data is suppressed and was reconstructed through the use of Statistics Canada catalogue 15-546, *Interprovincial and International Trade in Canada, 1992-1998*, which contains matrices of total interprovincial trade flows (goods and services together). Goods were separated from services on the basis of 1997 shares of goods in total regional exports. These shares were specific both to exporting and importing provinces; this estimation method was found to be superior to other methodologies considered, such as constant average shares or time-based shares, as the goods/service ratio in trade was found to be relatively stable for specific provincial pairs. These reconstructions make 1992-1996 the "middle" data period where some concerns over data quality remain due to suppressed values and the use of SIC classification. In the "late" 1997-2003 period interprovincial trade data are complete, estimated on NAICS basis and expected to be the best currently available data on the intranational trade flows.

All the data described includes intraregional trade flows, i.e. the shipments of every region to itself that are necessary for estimating the specification.

4.3 U.S.-Canada Regional Trade

These data are constructed following the approach of McCallum and Helliwell. The interprovincial goods trade matrix from the Input-Output Division (see above) also contains total exports to the world by province. This is combined with the international trade flows information (merchandise trade catalogues 65-202 and 65-203 from the International Trade Division of Statistics Canada, and Strategis Trade Data Online) which contains all the province-state flows. The latter source is based on customs data, which is by province of clearance – therefore the final destination of shipments remains more or less unknown. Therefore, the IT province-state trade is adjusted to match the more reliable totals from the I-O data.

Some of the shipments data are either too low or unobservable and are not reported. These missing observations occur only for a select number of small jurisdictions: Newfoundland and Prince Edward Island on Canadian side, and North Dakota, Montana, Arizona and a few other states on the U.S. side. These empty cells are primarily a zero data problem rather than missing data; following the practice of previous research, we eliminate the seventeen (17) observations where trade flows are 0 in any year between 1988 and 2003 for all years (272 observations in all, or less than 2.5% of the total of 11040). We have estimated variations on this approach: replacing missing data with zeros, partial elimination of the consistently missing data only, as well as complete elimination of all Newfoundland and PEI observations. The results vary somewhat across specifications, but all of our qualitative conclusions remain valid.

4.4 U.S. Trade Data

The only U.S. source of data comparable to Canadian intranational trade is the Commodity Flow Survey (CFS) by the U.S. Census Bureau. It estimates both intrastate and interstate shipments of goods by surveying the total shipping activity of domestic manufacturing, mining, wholesale and selected retail establishments every five years. The use of the CFS for estimating border effects was pioneered by Hillberry (1998) and has been used in several papers since, among them Anderson and van Wincoop (2001).

There are important distinctions between merchandise trade data and the shipments data reported by the CFS. The survey excludes some commodities, a part of mining and the whole of agriculture. Secondly, shipments destined for international destinations are still recorded if they are shipped domestically prior to leaving the United States, and imported shipments are similarly tracked from the port of entry to final destination. Finally, and most importantly, the survey tracks simply freight shipments, without claiming that the goods originate at the source. Thus the same product can be shipped multiple times between extractors, manufacturers, wholesalers, distributors and retailers. This inflates the value of shipments reported by CFS significantly.

Due to these large differences between trade and shipments data, as well as time period requirements (in the relevant time period 1988-2003, only three CFS datasets are available: 1993, 1997 and 2002), CFS interstate shipments data are not used in this paper. However, the use of the internal shipments (sent by states to themselves), which are available in the CFS data, is necessary to estimate intrastate trade flows for the final specification. Because of the trade inflation problem, an adjustment is necessary to bring CFS in line with other trade data. Following Helliwell (1997, 1998) and AvW (2001), we adjust CFS shipments data by the ratio of total U.S. domestic merchandise trade to total domestic shipments from the CFS. Domestic merchandise trade is estimated by subtracting merchandise exports from gross output in mostly goods producing sectors (agriculture, mining and manufacturing). This methodology produces adjustment factors of 3025/5846 for CFS 1993, 3550/6944 for CFS 1997 and 3606/8397 for CFS 2002. Scaling down by these factors, we obtain intrastate trade estimates for thirty U.S. states for these years.

To derive these estimates for all years, we first construct a measure of gross output by state (which is not available otherwise). Nationwide ratios of gross output to GDP by sector (agriculture, mining and manufacturing) are derived for every year, and then applied to state-specific GDP by sector. Then, considering the ratio of internal shipments to gross output a stable measure (which is confirmed through the existing CFS data), we use it to estimate internal shipments for each state for all other years between 1988 and 2003.

5 Estimation Results

The specification obtained in section 3 is estimated first in a cross-sectional manner, separately for every year in order to achieve comparability with previous results. This is followed by aggregate estimation using panel data techniques. Largely due to data concerns for some of the earlier years, but also to provide more manageable results, the panel is initially subdivided into three parts: 1988-1991, 1992-1996, and 1997-2003. We report the individual cross-sectional results together with the panel results for these time periods. After presenting these estimates, we then estimate the whole 1988-2003 period as one panel. This is followed by the estimation of border effects separately by province to test the size of the border effect for different jurisdictions. Next, we estimate border effects for imports and exports separately to account for the fact that the border might have a different resistance to North-South flows than vice versa. Lastly, we introduce time effects into the equation and chart the evolution of border effects through time.

5.1 Estimation Methods

Gravity equation estimation techniques vary in the literature; Helliwell (1988) and others find that simple ordinary least squares (OLS) estimates produce very similar results to those obtained using more advanced econometric methods. This is also confirmed by our results. After estimating with OLS first (with robust standard errors to correct for heteroskedasticity in the data), we consider other techniques that may be more appropriate and compare the results.

We first consider the panel data *fixed effects* model, using the *within* estimator, which is consistent and unbiased. Fixed effects models generally control for heterogeneity in the panel which is due to unobservable characteristics of the individual cases that are omitted from the model and do not vary over time. Introduction of full fixed effects is equivalent to defining a dummy variable for each case, eliminating all the between-cases variation from the estimation and keeping only the within-cases variation. While the fixed effects models are widely used with panel data, its use on our regional trade data must be accompanied by some reservations. There is a great deal of within-group variation, particularly for smaller trading units, that can only be interpreted as "noise"; also, the variation with time is not large compared to between-group variation. Lastly, the use of full fixed effects is not effective in our case, as the border effect dummy and several other variables of interest are time-invariant and therefore are dropped during the transformation. Due to the above considerations, we implement a reduced fixed-effects model (which specifies a fixed effect for the presence of individual regions in the trading pair) as an additional specification.

The within estimator serves as a benchmark for the Hausman test which determines the appropriateness of the *random effects* model, which uses the estimator that is a weighted average of within and between effects. The result of the test shows that the random effects estimators are inconsistent and therefore the random effects model is not appropriate in this case.

We next consider the technique of Feasible Generalized Least Squares (FGLS). Just as the robust OLS, it produces consistent estimates, which will, however, be more efficient under the assumption of panel heteroskedasticity and thus preferred to the robust OLS.

To address the problem of heteroskedasticity of unknown form with instrumental variables, we also use the generalized method of moments (GMM) estimator which produces efficient estimates in this context.

Generally, all three estimators (robust OLS, FGLS with and without fixed effects, and GMM) produce very similar results throughout this study; this includes signs of coefficients, their significance and even their relative magnitude. Cases that exhibit significant differences from this pattern are discussed in the estimation description below. Our overall conclusion is that the use of OLS, despite its theoretical limitations, produces a viable approximation to the results obtained from more advanced techniques, and that OLS estimates may be relied upon in most cases in the context of our model.

5.2 Static Border Effects in a Regional Model

We present estimation results by periods, with cross-sectional results for border effects followed by period panel estimates in the same table. Table 1 shows the results for the years 1988-1991. Equations *(i)* to *(iv)* present the cross-sectional effects for the individual years, equation *(v)* is a robust OLS estimation of the four-year panel, *(vi)* is a panel estimation with FGLS, and *(vii)* is the instrumental variable-GMM method. Under simple cross-sectional OLS, the border effect dummy takes the value of -1.81 in 1988.

The coefficient sign is negative as expected, since the dummy takes the value of 1 for cross-border flows. The exponent of the absolute value of the coefficient is the border effect, which equals 6.1 in 1988. This border effect exhibits little variation over the next three years, reaching a marginally smaller effect of 5.7 by 1991. All of the border dummy coefficients are significant at 1%.

Other variables generally behave as expected and exhibit significant coefficients with theoretically appropriate signs. The coefficients for the relative production variable are between 0.96 and 0.91, which is close to the theoretically expected value of 1. The effect of relative prices is negative, varying between -2.4 and -4.6; both relative production and relative price are significant at 1%.

Table 1. Canada - U.S. Border Effects, 1988-1991

	Equations						
Year / Method	**1988**	**1989**	**1990**	**1991**	**OLS**	**FGLS Het.**	**GMM**
	(i)	*(ii)*	*(iii)*	*(iv)*	*(v)*	*(vi)*	*(vii)*
Border	-1.81*	-1.73*	-1.83*	-1.74*	-0.67*	-0.76*	-0.43*
	(0.16)	*(0.14)*	*(0.14)*	*(0.13)*	*(0.12)*	*(0.04)*	*(0.15)*
Rel. Production	0.96*	0.94*	0.91*	0.95*	0.99*	0.97*	1.01*
	(0.04)	*(0.04)*	*(0.04)*	*(0.04)*	*(0.02)*	*(0.01)*	*(0.03)*
Rel. Prices	-2.39*	-2.65*	-4.57*	-4.55*	-1.72*	-1.86*	-1.32
	(0.76)	*(0.77)*	*(0.92)*	*(0.61)*	*(0.40)*	*(0.14)*	*(0.71)*
Government	14.91*	13.17*	9.44*	11.07*	10.98*	10.61*	9.79*
	(0.87)	*(0.88)*	*(0.67)*	*(0.72)*	*(0.37)*	*(0.14)*	*(0.60)*
Not Adjacent	-0.96*	-0.97*	-0.86*	-0.89*	-0.86*	-0.73*	-0.80*
	(0.19)	*(0.18)*	*(0.19)*	*(0.18)*	*(0.09)*	*(0.03)*	*(0.11)*
Distance	-0.94*	-0.90*	-1.02*	-1.00*	-1.01*	-1.01*	-1.06*
	(0.08)	*(0.08)*	*(0.08)*	*(0.08)*	*(0.04)*	*(0.01)*	*(0.05)*
Tariffs					-36.87*	-34.38*	-44.56*
					(2.97)	*(1.01)*	*(4.12)*
Constant	0.22	-0.04	-0.04	0.15	0.02	-0.11*	-0.06
	(0.21)	*(0.20)*	*(0.20)*	*(0.21)*	*(0.10)*	*(0.04)*	*(0.13)*
Observations	673	673	673	673	2692	2692	2692
R-squared	0.66	0.66	0.63	0.67	0.66		
Border Effect	**6.1**	**5.6**	**6.2**	**5.7**	**2.0**	**2.1**	**1.5**

*Robust standard errors in parentheses; * denotes significance at 1%*
17 observations with 0 observed trade have been deleted

Distance and lack of adjacency both exhibit negative coefficients close to -1, and are also significant at 1%. Of note is the strong positive impact on trade of the relative government share. Its coefficient varies between 9 and 14 and is significant at 1%. Note also that the constant term is not significant in the estimates; this is consistent with the fact that the specification being estimated does not contain a constant term. It is still included to avoid bias; however its lack of significance is an encouraging sign.

Linguistic affinity L is the only variable whose inclusion does not result in strong conclusions one way or the other. The initial specification of L, discussed in the data section, resulted in non-significant coefficients close to zero. This was thought due to the lack of interaction between the second languages (French and Spanish) in the regional model. With state-to-state trade excluded from estimation, Canadian provinces with French-language minorities do not interact significantly with U.S. states, whose linguistic minorities of significant size are Spanish only. The only trading pair out of 673 observations that is likely to pick up the full intended effect of the linguistic affinity variable is thus Quebec and New Brunswick. An alternative specification for L was considered, with dummies equal to 1 for regions with linguistic minorities above 10%, and 0 otherwise. This modification resulted in language actually having a significant negative effect for some of the years, and insignificant effect for others.

This weak result may be due the two opposite effects of language (and the social networks and customs it is meant to represent) on trade. On one hand, trade in differentiated goods is expected to be higher between similar regions; on the other hand, different languages and customs may lead to a greater degree of differentiation among the varieties of goods, which may promote trade. This model and most standard models of monopolistic competition do not allow for the second effect. We incline, however, to a simpler explanation: the nature of the predominantly English-speaking regions examined in the model prevents a meaningful evaluation of the effect of this variable. There is simply not enough variation in the sample to identify the parameter. Better results are to be expected in an OECD setting. We decide to exclude it from our final specification in order to avoid additional multicollinearity; it should be noted, however, that including language in any specification does not affect the estimates for other variables to any degree, nor their significance.

Table 1 also reports estimation results for 1988-1991 as OLS, FGLS with heteroskedasticity correction and GMM panels as equations *(v)* to *(vii)*; this setup allows us to include the tariffs variable into the equation. As expected, tariffs have a strong negative impact on trade in all the specifications. The inclusion of tariffs has a large impact on the border dummies coefficient, but does not greatly affect any other variables.[7] The border effect as a result of tariff introduction is reduced from the cross-sectional estimates of about 6 to 2.0 in OLS, 2.1 in FGLS and 1.5 in GMM.

This result shows that explicitly specifying tariffs as an explanatory variable in the equation rather than leaving it out as an unexplained component of border effects reduces the estimated border effect in 1988 roughly from 6 to 2. It is an even more remarkable result when one considers that the average tariff levels in this year was at only about 2.5% for U.S. and 4.5% for Canada, and rapidly declined from there. We deal with the effect of tariff more extensively in the time series estimation section, but this basic result remains unchanged. Although some studies, like Helliwell (1988), have inferred that the declining tariffs may be responsible for the decrease in border effects, and others such as Fairfield (2001) have shown that with certain elasticity assumptions tariffs may be responsible for a large portion of border effects, we present for the first time an empirical result which states that two-thirds of the border effect is explained by a rather small tariff level.

Table 2 presents the results from the 1992-1996 panel. These are very similar to the earlier period. The year-to-year border effect has declined very slightly, and is between 5 and 5.8, while all the other variables retain their significance and size. However, panel estimates in equations *(vi)* to *(viii)* show an increase in the border effect to 3.5-3.8, which is almost double that of the 1988-1991 panel levels.

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[7] In fact, the coefficient on relative production in those equations is for all intents and purposes equivalent to its theoretically expected value of 1.

Table 2. Canada - U.S. Border Effects, 1992-1996

	Equations							
Year / Method	**1992**	**1993**	**1994**	**1995**	**1996**	**OLS**	**FGLS Het.**	**GMM**
	(i)	*(ii)*	*(iii)*	*(iv)*	*(v)*	*(vi)*	*(vii)*	*(viii)*
Border	-1.71*	-1.60*	-1.64*	-1.76*	-1.69*	-1.25*	-1.34*	-1.27*
	(0.13)	*(0.14)*	*(0.13)*	*(0.14)*	*(0.15)*	*(0.07)*	*(0.03)*	*(0.09)*
Rel. Production	0.93*	0.91*	0.88*	0.88*	0.86*	0.90*	0.91*	0.91*
	(0.03)	*(0.03)*	*(0.03)*	*(0.03)*	*(0.03)*	*(0.01)*	*(0.00)*	*(0.02)*
Rel. Prices	-4.02*	-4.20*	-4.78*	-4.95*	-5.90*	-3.90*	-4.06*	-4.08*
	(0.51)	*(0.50)*	*(0.49)*	*(0.50)*	*(0.60)*	*(0.25)*	*(0.10)*	*(0.33)*
Government	10.08*	8.08*	6.84*	8.36*	7.35*	7.77*	7.56*	7.92*
	(0.56)	*(0.47)*	*(0.45)*	*(0.46)*	*(0.47)*	*(0.22)*	*(0.09)*	*(0.28)*
Not Adjacent	-0.84*	-0.76*	-0.66*	-0.53*	-0.66*	-0.68*	-0.52*	-0.67*
	(0.18)	*(0.18)*	*(0.17)*	*(0.18)*	*(0.18)*	*(0.08)*	*(0.03)*	*(0.10)*
Distance	-0.99*	-1.03*	-1.08*	-1.16*	-1.08*	-1.08*	-1.10*	-1.08*
	(0.07)	*(0.08)*	*(0.07)*	*(0.07)*	*(0.08)*	*(0.03)*	*(0.01)*	*(0.04)*
Tariffs						-41.00*	-39.60*	-39.75*
						(4.11)	*(1.45)*	*(4.75)*
Constant	0.29	0.20	0.22	0.71*	0.39	0.32*	0.28*	0.35*
	(0.20)	*(0.20)*	*(0.19)*	*(0.21)*	*(0.20)*	*(0.09)*	*(0.03)*	*(0.12)*
Observations	673	673	673	673	673	3365	3365	3365
R-squared	0.69	0.67	0.67	0.67	0.65	0.67		
Border Effect	**5.5**	**5.0**	**5.2**	**5.8**	**5.4**	**3.5**	**3.8**	**3.6**

*Robust standard errors in parentheses; * denotes significance at 1%*
17 observations with 0 observed trade have been deleted

This result is consistent with the overall evidence, but requires explanation. If the decline in tariffs was the only new factor in 1992-1996, then the cross-sectional border effects in equations *(i)* to *(v)* should have declined significantly, and the panel effects correcting for tariffs should have remained constant. But the former remained stable, and the latter increased. This means that both of these border effects are pushed upwards by some unobserved factor not included in the model. The most natural explanation would be that as the tariffs have declined and their contribution to the cross-sectional border effect decreased, other factors such as non-tariff barriers (NTB) have been increasing in place of tariffs. Since usable time-series data on NTBs are not available, this must remain only a conjecture at the moment; yet it may be another piece of evidence, similar to McCallum's original demonstration, that casts doubt upon the picture of smooth transition from a national to a North American economy for the U.S., and especially for Canada.

Table 3. Canada - U.S. Border Effects, 1997-2003, cross-sectional

	Equations						
Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
	(i)	*(ii)*	*(iii)*	*(iv)*	*(v)*	*(vi)*	*(vii)*
Border	-1.63*	-1.62*	-1.62*	-1.55*	-1.64*	-1.61*	-1.60*
	(0.14)	*(0.13)*	*(0.13)*	*(0.15)*	*(0.14)*	*(0.13)*	*(0.15)*
Rel. Production	0.95*	0.93*	0.98*	0.95*	0.94*	0.92*	0.83*
	(0.03)	*(0.03)*	*(0.03)*	*(0.04)*	*(0.04)*	*(0.03)*	*(0.04)*
Rel. Prices	-6.93*	-5.62*	-7.69*	-13.44*	-11.55*	-10.33*	-9.68*
	(0.57)	*(0.44)*	*(0.53)*	*(1.05)*	*(0.99)*	*(0.68)*	*(0.94)*
Government	8.03*	7.17*	7.97*	8.27*	6.71*	7.47*	8.32*
	(0.48)	*(0.44)*	*(0.45)*	*(0.59)*	*(0.53)*	*(0.49)*	*(0.69)*
Not Adjacent	-0.78*	-0.75*	-0.77*	-1.00*	-1.05*	-1.04*	-1.28*
	(0.18)	*(0.18)*	*(0.18)*	*(0.18)*	*(0.18)*	*(0.18)*	*(0.20)*
Distance	-1.02*	-1.00*	-0.99*	-0.86*	-0.83*	-0.85*	-0.70*
	(0.08)	*(0.08)*	*(0.08)*	*(0.08)*	*(0.08)*	*(0.07)*	*(0.08)*
Constant	0.43	0.39	0.57*	0.45	0.40	0.53*	0.26
	(0.21)	*(0.20)*	*(0.21)*	*(0.22)*	*(0.22)*	*(0.20)*	*(0.22)*
Observations	673	673	673	673	673	673	673
R-squared	0.66	0.66	0.67	0.63	0.61	0.64	0.53
Border Effect	**5.1**	**5.1**	**5.1**	**4.7**	**5.2**	**5.0**	**5.0**

*Robust standard errors in parentheses; * denotes significance at 1%*
17 observations with 0 observed trade have been deleted

Cross-sectional border effects remained very stable in the last period of the sample, 1997-2003 (Table 3), on average equal to 5. Looking back at the whole period, we can conclude that cross-sectional border effects underwent a small and slow decline from 6.1 in 1988 to 5.0 in 2003. But is does not mean that border effects remained unaffected during this period; on the contrary, we are aware of at least two competing influences: declining tariffs[8] had a downward impact, and unexplained factors had the opposite effect. The overall picture is not one of sharp decline as claimed in the earlier literature, but of a prolonged, gradual downward slide which occasionally reverses itself, as in 1995 and 2001. There are few changes in the behaviour of the other variables; we may note the decline in the distance coefficient, implying cheaper transportation in the last year of the sample. We are hesitant to make much of it, especially in light of the recent meta-analysis in Head & Disdier (2006) showing persistently high, stable transportation elasticities since 1950; we only note with some satisfaction that their average distance effect estimate of -0.9 is exactly the same average effect that we obtain. There are some relatively large deviations in coefficients in 2003, the last year of the sample; the fact that the interprovincial trade data for 2003 is preliminary and recent may account for a large part of this effect.

[8] These have generally reached 0 by 1998, with some exceptions due to NAFTA rules-of-origin regulations. Some transaction costs involved in avoiding very small tariffs exceed

Table 4. Canada - U.S. Border Effects, 1997-2003, panel

	Equations		
Method	**OLS**	**FGLS Het.**	**GMM**
	(i)	*(ii)*	*(iii)*
Border	-1.57*	-1.55*	-1.59*
	(0.05)	*(0.03)*	*(0.07)*
Rel. Production	0.90*	0.89*	0.95*
	(0.01)	*(0.01)*	*(0.02)*
Rel. Prices	-7.67*	-7.63*	-9.13*
	(0.26)	*(0.13)*	*(0.39)*
Government	7.45*	6.98*	8.00*
	(0.20)	*(0.10)*	*(0.27)*
Not Adjacent	-0.98*	-0.84*	-0.93*
	(0.07)	*(0.03)*	*(0.09)*
Distance	-0.88*	-0.87*	-0.90*
	(0.03)	*(0.01)*	*(0.04)*
Tariffs	-109.03*	-95.41*	-100.86*
	(22.51)	*(8.92)*	*(22.39)*
Constant	0.37*	0.16*	0.51*
	(0.08)	*(0.04)*	*(0.11)*
Observations	4711	4711	4711
R-squared	0.61		
Border Effect	**4.8**	**4.7**	**4.9**

*Robust standard errors in parentheses; * denotes significance at 1%*
17 observations with 0 observed trade have been deleted

The panel effects for 1997-2003 in Table 4 are very similar to Table 3 estimates; this is consistent with tariffs declining to 0 early on in this period, and the stable behaviour of the cross-sectional estimates. Table 4 shows that the panel border effect estimated for these years is close to 5. All the estimation methods give similar results, all the variables take expected signs and all are significant at 1% level of confidence.[9]

The evidence from three separate panels allows us to largely discard our previous concerns about data compatibility. The estimates for all variables are generally in line and there are no sharp jumps in the cross-sectional estimates. This allows us to pool all the data for 1988-2003 and estimate it as a sixteen-year panel (Table 5).

[9] The high coefficient on the tariff variable is due to the low initial size of the tariffs, and their decline to 0 shortly thereafter; in effect, it represents the high marginal impact of a near-zero tariff.

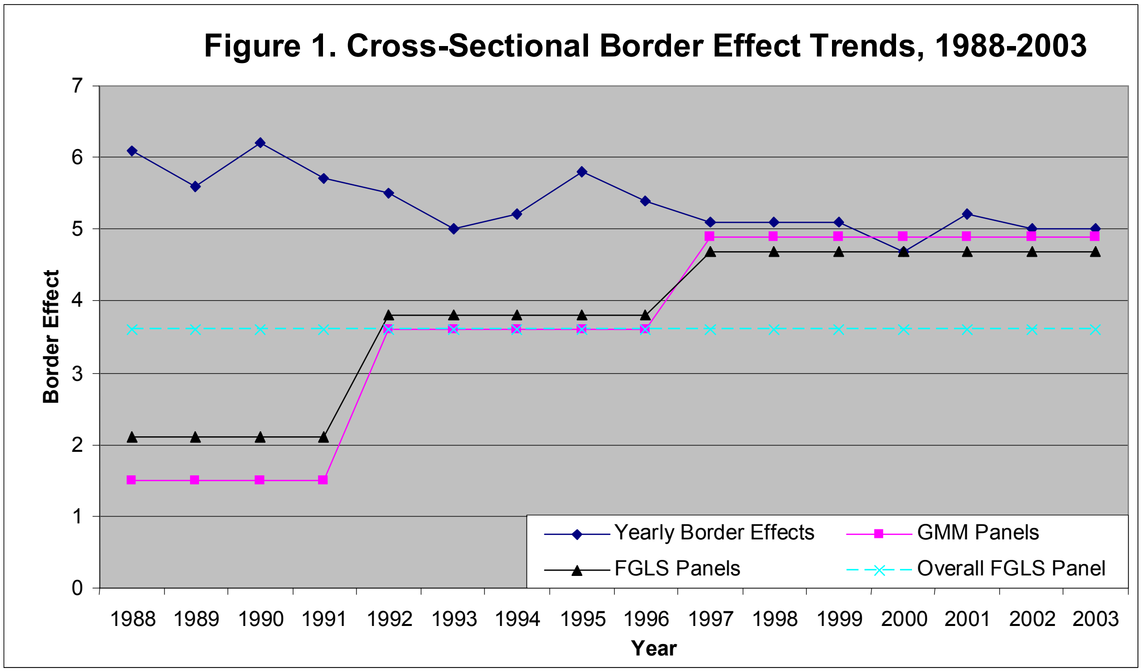
Table 5. Canada - U.S. border effect panels, 1988-2003

	Equations		
Method	**OLS**	**FGLS Het.**	**GMM**
	(i)	*(ii)*	*(iii)*
Border	-1.26*	-1.29*	-1.26*
	(0.04)	*(0.02)*	*(0.05)*
Rel. Production	0.88*	0.87*	0.91*
	(0.01)	*(0.00)*	*(0.01)*
Rel. Prices	-5.14*	-5.21*	-5.93*
	(0.16)	*(0.09)*	*(0.23)*
Government	7.64*	6.99*	7.94*
	(0.14)	*(0.08)*	*(0.20)*
Not Adjacent	-0.85*	-0.64*	-0.81*
	(0.05)	*(0.02)*	*(0.06)*
Distance	-0.98*	-1.00*	-1.01*
	(0.02)	*(0.01)*	*(0.03)*
Tariffs	-36.98*	-34.19*	-37.51*
	(0.99)	*(0.51)*	*(1.28)*
Constant	0.19*	-0.00	0.27*
	(0.05)	*(0.03)*	*(0.07)*
Observations	10768	10768	10768
R-squared	0.63		
Border Effect	**3.5**	**3.6**	**3.5**

*Robust standard errors in parentheses; * denotes significance at 1%*
17 observations with 0 observed trade have been deleted

Table 5 presents the results of this estimation. The border coefficient is estimated at -1.3 with all three techniques, and the implied Canada-U.S. border effect is 3.5-3.6 for these sixteen years as a whole. Predictably, all other coefficients are significant and their values close to those already discussed.

It is helpful to summarize the results described so far in this subsection graphically. Figure 1 shows, first, the slow decline of the cross-sectional border effect estimates from 6 to 5, the three separate FGLS and GMM panels, both showing the increase in border effects estimates that take tariffs into account, and the overall average border effect of 3.6 (exponent of the absolute value of -1.29, the FGLS coefficient) for the 1988-2003 period. By 1997, with the effect of tariffs gone, the yearly and the panel estimates converge at 5, but the tariff decrease only accounts for the decline of yearly effects from 6 to 5, while the rise in the unexplained factors (presumably NTB) is responsible for the increase in panel estimates from 2 to 5.



These estimates do not take the influence of time into account, and are primarily interesting for comparability with previously reported cross-sectional border effects estimated on a year-to-year basis. The results of direct influence of time on trade and border effects are reported in the next subsection.

5.3 Evolution of Border Effects with Time, 1988-2003

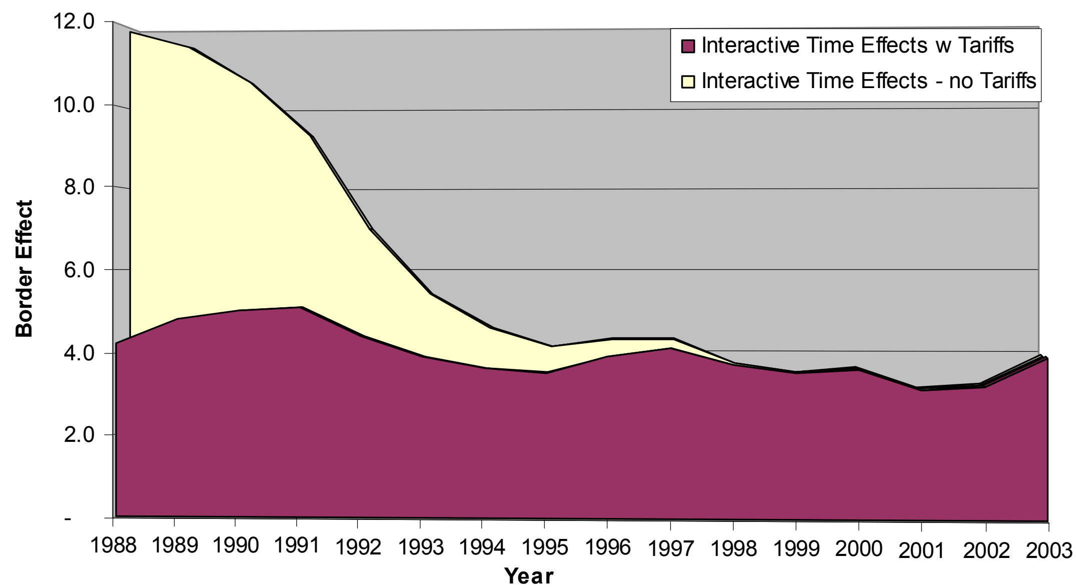
While the gradual elimination of merchandise trade tariffs following the Canada-U.S. FTA predictably led to the convergence of the yearly and panel estimates towards the end of the period at values around 5, it was remarked in the previous subsection that the panel estimates accounted for the greater portion of this convergence. Thus the existing tariffs, small though they were, used to account for a major portion of the border effect. Now their share of the border effect has been replaced by nearly as powerful trade-restricting effects that are not explained by the model. Possible explanations include non-tariff barriers and/or unaccounted-for changes in consumer preferences; these are of interest for further research.

In this subsection we wish to focus on the time dimension of the model. We are in possession of an unprecedented sixteen years of cross-sectional time series for Canada-U.S. trade and its time dynamics are crucial in helping us answer our research question. Once again, we will use OLS, FGLS and GMM, and also a combination of time-fixed and interaction time effects.

To begin with, we answer a smaller but revealing question: what exactly is the impact of tariffs on the size of border effect in a time-series context? We address this question by allowing the border dummy to vary with time (interaction time effects), but do not introduce fixed time effects in order to obtain results comparable to the earlier literature. Then we estimate the 1988-2003 panel in FGLS (our preferred estimation method) with tariffs in the equation, and without. Figure 2 presents the results.

The estimated border effects with and without tariffs are the same at the end of this time period, as expected, but at the beginning there is a large gap between those estimates that control for tariffs and those that do not. Tariff inclusion decreases the border effect from about 12 in 1988 to roughly 4. That is the same factor of two-thirds as was shown earlier.

Figure 2. Tariff Impact on Border Effect Estimates (FGLS)



We are now in a better position to decompose the effect of changes introduced by this study compared to the earlier studies of McCallum (1995), Helliwell (1997) and Helliwell (1998). All three obtained very high border effects in 1988 (between 20 and 22), and the last two found sharply declining border effects after 1988. We explain the discrepancy between our results and theirs in two stages. First, the specification estimated here relies on a theoretical derivation of a regional trade model and is producing results that have direct theoretical interpretation, unlike the empirical versions of the gravity equation.[10] This discrepancy accounts for the difference between our border effect of 12 for 1988 and the early literature's approximate consensus at 20. Secondly, tariffs were not explicitly a part of the gravity equation in the earlier literature. Tariffs can only be included in panel data estimation, and this fact alone limits the scope and usefulness of

[10] This includes the fact that our regional model has more explanatory variables as a result of theoretical derivation, such as prices and government.

single-year cross-sectional estimates obtained by previous studies. The difference that tariff inclusion makes, as shown by Figure 2, would account for the second part of the aforementioned discrepancy, reducing the border effect estimate from 12 to 4.

However, this result is derived only for illustration purposes and is not our preferred answer to the question "what was the true border effect in 1988?" The use of interaction time effects allows the border effect to vary from year to year as a result of various factors not captured by the model – political and economic climate, random events etc. These same effects, however, can have a direct influence on the dependent variable of our specification – the volume of trade. To take these into account, we estimate the panel with fixed time effects only, interaction time effects only, and then both together.

The results of this estimation are presented in Table 6. Equation *(i)* is our baseline FGLS model seen earlier in Table 5 and Figure 1, without time effects. Equation *(ii)* introduces fixed time effects for each year (save one). These time dummies (coefficients not reported to save space) have, after the first few years, a strong positive effect on trade. This means trade was increasing with time independently of all the explanatory variables, either as a result of shocks or through a link with variables not controlled for by the specification. Once the fixed time effects are controlled for, the average border effect rises from 3.6 to 4.6; the only other change is the halving of the tariff coefficient from -34 to -16.[11]

[11] This is not surprising - because tariffs were decreasing linearly with time, it would be natural for them to account for a portion of the time effect prior to its explicit introduction.

Table 6. Border Effects in Time-Series Context, FGLS, 1988-2003

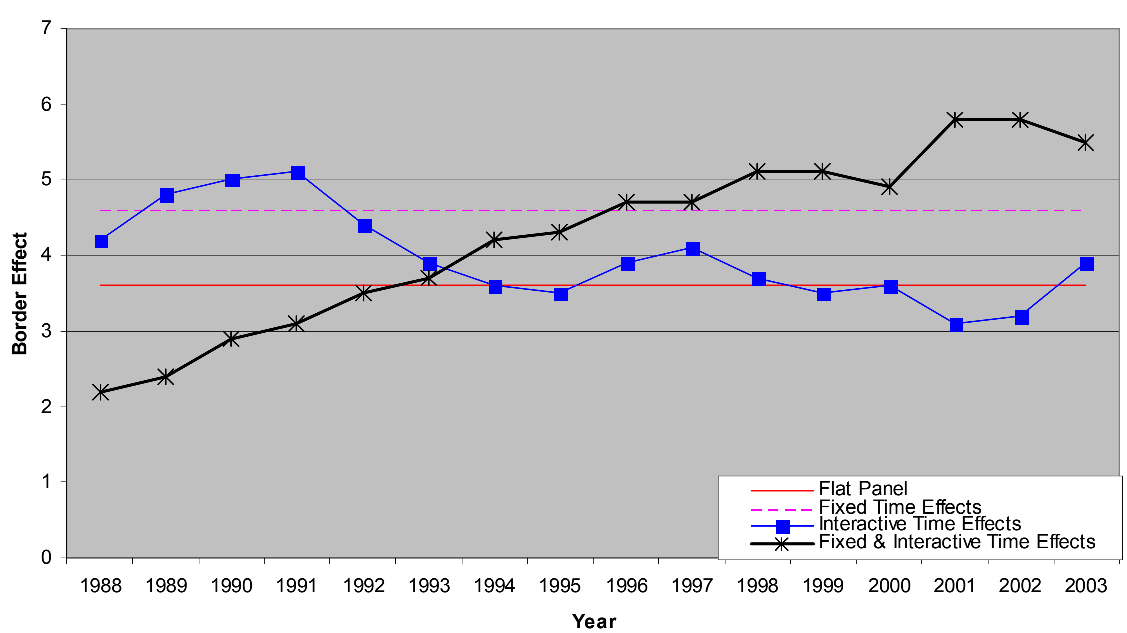
	(i)		*(ii)*		*(iii)*		*(iv)*	
	Baseline	**Border Effect**	**Fixed Time Effects**	**Border Effect**	**Interaction Time Effects**	**Border Effect**	**Fixed & Interaction Time Effects**	**Border Effect**
B	-1.29*	**3.6**	-1.52*	**4.6**				
	(0.02)		(0.02)					
B1988					-1.44	**4.2**	-0.78	**2.2**
B1989					-1.56	**4.8**	-0.88	**2.4**
B1990					-1.61	**5.0**	-1.08	**2.9**
B1991					-1.62	**5.1**	-1.14	**3.1**
B1992					-1.48	**4.4**	-1.25	**3.5**
B1993					-1.36	**3.9**	-1.30	**3.7**
B1994					-1.28	**3.6**	-1.44	**4.2**
B1995					-1.26	**3.5**	-1.47	**4.3**
B1996					-1.37	**3.9**	-1.55	**4.7**
B1997					-1.41	**4.1**	-1.54	**4.7**
B1998					-1.30	**3.7**	-1.62	**5.1**
B1999					-1.26	**3.5**	-1.63	**5.1**
B2000					-1.29	**3.6**	-1.59	**4.9**
B2001					-1.13	**3.1**	-1.76	**5.8**
B2002					-1.15	**3.2**	-1.75	**5.8**
B2003					-1.37	**3.9**	-1.71	**5.5**
Rel. Production	0.87*		0.87*		0.87*		0.88*	
	(0.00)		(0.00)		(0.00)		(0.00)	
Rel. Prices	-5.21*		-5.24*		-5.21*		-5.15*	
	(0.09)		(0.09)		(0.10)		(0.10)	
Government	6.99*		7.45*		7.17*		7.51*	
	(0.08)		(0.08)		(0.08)		(0.08)	
Not Adjacent	-0.64*		-0.70*		-0.65*		-0.69*	
	(0.02)		(0.02)		(0.02)		(0.02)	
Distance	-1.00*		-0.97*		-0.99*		-0.98*	
	(0.01)		(0.01)		(0.01)		(0.01)	
Tariffs	-34.19*		-15.70*		-27.39*		-28.20*	
	(0.51)		(0.91)		(1.45)		(1.45)	
Constant	-0.00		-0.37*		0.02		-0.58*	
	(0.03)		(0.04)		(0.03)		(0.05)	
Observations	10768		10768		10768		10768	

*Robust standard errors in parentheses; * denotes significance at 1%*
17 observations with 0 observed trade have been deleted

Equation *(iii)* introduces interaction time effects into the baseline model; the resulting border effects are those shown in Figure 2. That equation results in a largely stable border effect through time, but with ups and downs that mirror the business cycle: spikes can be clearly seen in 1991, 1997 and 2002-2003. This demonstrates that there are fixed time effects in the data that need to be accounted for; thus we add fixed time effects to the interaction effects to obtain equation *(iv)*.

Equation *(iv)* produces our final preferred estimates for 1988-2003 border dummies and all other coefficients. It reports a consistent increase in the border effect between Canada and U.S. from a 2.2 level in 1988 (exponent of 0.78) to 5.5 in 2003 (exponent of 1.71). A significant jump occurs in 2001 (from 4.9 to 5.8), and a slight drop in 2003 (from 5.8 to 5.5) – except for those, it is a smooth increasing trend. This contrasts both with the earlier conclusions of the literature about declining border effects, and with the stable pattern estimated by equation *(iii)*. Border effects from all four equations of Table 6 are presented in Figure 3. Other coefficients are similar to those discussed in the previous subsection; non-adjacency has a somewhat smaller role in this specification, but is still negative and significant.

Figure 3. Time Impact on Border Effects Estimates (FGLS)



Having decomposed above the transition from the McCallum effect of 22 to the equation *(iii)* effect of 4 in 1988, we now must explain this last step between equation *(iii)* and equation *(iv)*. The only difference between those is in the inclusion of fixed time effects in equation *(iv)*. Because the trade data contains a time-dependent pattern (fixed time effects are, once again, positive and significant after the first few years), accounting for fixed time effects leaves less trade to be explained by the rest of the model. That in turn revises the finding of stable border effect to a finding of an increasing effect. In other words, trade has risen faster than predicted by the gravity equation during this period (which is consistent with the picture of relative growth in world trade since 1945), but not because the border effect between Canada and U.S. decreased; it is shown that this effect has actually increased throughout.

Lastly, we also consider a model with regional fixed effects. As the full fixed-effects model would eliminate time-invariant variables like distance, adjacency and the border dummy itself, a reduced model is specified. The presence of a particular region in the trading pair sets the value of its dummy variable to 1. We introduce fixed effects into the FGLS estimation as conducted in Table 6, and report the results in Table 7.

Overall, these results exhibit similar trends and levels to previous estimates. The coefficient on relative production is markedly lower than the theoretical value of one; the role of adjacency is greater, while those of distance and government are smaller. The time path of the border effect estimates is somewhat smoother, but still trending in the same direction – from 2.4 in 1988 to 4.9 in 2003.

Table 7. Regional and Time Fixed Effects Panel, FGLS, 1988-2003

	(1)		(2)		(3)		(4)	
	Baseline	**Border Effect**	**Fixed Time Effects**	**Border Effect**	**Interactive Time Effects**	**Border Effect**	**Fixed & Interactive Time Effects**	**Border Effect**
B	-1.23*	**3.4**	-1.43*	**4.2**				
	(0.04)		(0.04)					
B1988					-1.34	**3.8**	-0.89	**2.4**
B1989					-1.42	**4.1**	-1.00	**2.7**
B1990					-1.55	**4.7**	-1.25	**3.5**
B1991					-1.56	**4.8**	-1.32	**3.7**
B1992					-1.44	**4.2**	-1.32	**3.7**
B1993					-1.37	**3.9**	-1.34	**3.8**
B1994					-1.28	**3.6**	-1.37	**3.9**
B1995					-1.26	**3.5**	-1.37	**3.9**
B1996					-1.31	**3.7**	-1.41	**4.1**
B1997					-1.30	**3.7**	-1.40	**4.1**
B1998					-1.21	**3.4**	-1.39	**4.0**
B1999					-1.19	**3.3**	-1.38	**4.0**
B2000					-1.19	**3.3**	-1.39	**4.0**
B2001					-1.13	**3.1**	-1.56	**4.8**
B2002					-1.15	**3.2**	-1.55	**4.7**
B2003					-1.26	**3.5**	-1.58	**4.9**
Rel. Production	0.67*		0.69*		0.67*		0.70*	
	(0.01)		(0.01)		(0.01)		(0.01)	
Rel. Prices	-4.84*		-4.75*		-4.85*		-4.74*	
	(0.09)		(0.09)		(0.09)		(0.09)	
Government	3.10*		3.95*		3.33*		3.97*	
	(0.12)		(0.12)		(0.12)		(0.12)	
Not Adjacent	-1.43*		-1.44*		-1.44*		-1.44*	
	(0.03)		(0.03)		(0.03)		(0.03)	
Distance	-0.67*		-0.66*		-0.66*		-0.66*	
	(0.01)		(0.01)		(0.01)		(0.01)	
Tariffs	-25.97*		-13.46*		-19.77*		-20.24*	
	(0.53)		(0.90)		(1.33)		(1.33)	
Constant	-0.97*		-1.02*		-0.92*		-1.25*	
	(0.05)		(0.06)		(0.06)		(0.07)	
Observations	10768		10768		10768		10768	

*Standard errors in parentheses; * significant at 1%*
17 observations with 0 observed trade have been deleted
Year and regional fixed effects are not reported
Baseline specification reported is for New Brunswick – Georgia trading pair which averages regional fixed effects at 0

Since fixed effects dummies have to exclude one province and one state, the size of the border effects in this specification greatly depends on the choice of the trading pair; in effect, presented values are the border effects between the members of the chosen trading pair. To avoid presenting misleading results, estimation was conducted for such a trading pair that makes the average of all other fixed effects zero; thus the selection of New Brunswick and Georgia as the baseline.[12]

Our conclusion to this subsection is that consistently estimated Canada-U.S. border effects have been increasing between 1988 and 2003. This fact was obscured in the earlier research by three factors: the exclusion of tariff data, lack of theoretical foundation for the specifications used, and lack of time dimension in the data and estimation procedures.

5.4 Border Effects by Province and Direction of Trade

From a general question "how strong is the border effect", we now turn to the estimation of the width of this border in different regions and different directions. A country-wide border effect may not do justice to the behaviour of individual regions; since a part of our research question is to investigate regional behaviour, we adapt our specification to this task. We restrict our equation only to observations concerning a particular province to come up with a set of individual border effects for Canadian provinces. Because we are looking for cross-sectional border effects, we restrict our

[12] The values of the coefficients on the fixed effects themselves (not included to save space) are generally below 1. Mild positive effects (and thus smaller border effects than average) are shown by the biggest U.S. states (California, New York, Michigan); larger than average effects occur for Canadian maritime provinces, the Western provinces have smaller than average effects. The regional breakdown of border effects is explored more fully in the next subsection.

sample period to 1997-2003 due to the lack of tariff influence in this period. Following Helliwell (1998), we simplify the model by constraining all our explanatory variables to be uniform throughout this seven-year period. Thus border effects are allowed to vary by time and by province; all other variables vary only by province.

The results of this estimation are presented in Table 8. To obtain a comparable benchmark, we estimate this specification for all of Canada first; the results are largely consistent with Table 3, the small differences due to the imposed restrictions. Provincial effects are then estimated individually in the West-East direction.

The results indicate some variability among the provinces in their border effects, with most of the provinces below the Canadian average of 5. All of the Canadian West (British Columbia, Alberta, Saskatchewan, Manitoba) exhibits smaller border effects than average, with Alberta the smallest at 2.7 in 2003. This is not surprising, as we should expect lower border effects for commodities, in which the West primarily specializes, rather than for manufactured goods, as observed by Helliwell (1998). However, Ontario and New Brunswick also follow this trend, and so does Quebec to a lesser extent. It is in the three relatively isolated Atlantic provinces, Newfoundland, Nova Scotia, and – to a lesser extent – Prince Edward Island – where the situation is reversed. The highest border effects occur consistently in Newfoundland, reaching above 20 in 2003. The relative isolation of these provinces undoubtedly contributes to higher border effects here, which significantly exceed those reported in Helliwell (1998), both in relative and absolute value. As a rule, border effects are flat between 1997 and 2003 for most provinces; but since the data represents static cross-sectional estimates, the inclusion of time effects would create an upward border effect trend in most if not all provinces.

Table 8. Border Effects by Province, 1997-2003

Province / Observations	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Canada: 673	ln(Rel.Prod.)=0.91 (70.85)		ln(Rel.Prices)=-7.7 (27.98)			ln(Gov.)=7.62 (41.38)	
	Not Adjacent=-0.97 (11.23)		ln(Distance)=-0.88 (28.38)				
Border	-1.60	-1.62	-1.58	-1.53	-1.69	-1.63	-1.63
t-value	(11.01)	(10.93)	(11.32)	(10.09)	(10.97)	(11.31)	(9.41)
R-squared	0.65	0.63	0.67	0.6	0.6	0.63	0.5
Border Effect	**5.0**	**5.1**	**4.9**	**4.6**	**5.4**	**5.1**	**5.1**
BC: 78	ln(Rel.Prod.)=0.94 (29.16)		ln(Rel.Prices)=-10.11(21.06)			ln(Gov.) = 7.33 (12.18)	
	Not Adjacent=-0.63 (3.77)		ln(Distance)=-0.53 (7.98)				
Border	-1.24	-1.34	-1.28	-1.20	-1.49	-1.49	-1.50
t-value	(5.45)	(6.05)	(6.43)	(5.71)	(7.43)	(7.64)	(6.80)
R-squared	0.69	0.69	0.77	0.74	0.77	0.79	0.72
Border Effect	**3.5**	**3.8**	**3.6**	**3.3**	**4.4**	**4.4**	**4.5**
AB: 78	ln(Rel.Prod.)=0.74 (15.98)		ln(Rel.Prices)=-4.9 (12.91)			ln(Gov.)=2.38 (3.05)	
	Not Adjacent=-0.41 (1.68)		ln(Distance)=-0.84 (8.99)				
Border	-1.10	-1.10	-1.09	-0.87	-0.96	-1.01	-1.01
t-value	(3.89)	(3.70)	(3.89)	(2.52)	(2.53)	(3.17)	(2.50)
R-squared	0.67	0.63	0.67	0.44	0.34	0.54	0.27
Border Effect	**3.0**	**3.0**	**3.0**	**2.4**	**2.6**	**2.7**	**2.7**
SK.: 78	ln(Rel.Prod.)=0.73 (18.04)		ln(Rel.Prices)=-8.68 (10.77)			ln(Gov.)=2.00 (2.51)	
	Not Adjacent=-0.84 (3.69)		ln(Distance)=-1.05 (9.63)				
Border	-1.27	-1.17	-1.15	-1.11	-1.28	-1.27	-1.28
t-value	(4.12)	(4.26)	(4.15)	(3.43)	(4.57)	(3.74)	(4.04)
R-squared	0.67	0.7	0.7	0.57	0.71	0.6	0.63
Border Effect	**3.6**	**3.2**	**3.2**	**3.0**	**3.6**	**3.6**	**3.6**
MB: 78	ln(Rel.Prod.)=0.80 (25.30)		ln(Rel.Prices)=-6.76 (8.00)			ln(Gov.)=4.49 (6.79)	
	Not Adjacent=-0.72 (4.95)		ln(Distance)=-1.03 (14.01)				
Border	-1.34	-1.40	-1.35	-1.36	-1.47	-1.33	-1.23
t-value	(6.12)	(6.29)	(6.53)	(6.09)	(6.87)	(6.79)	(5.92)
R-squared	0.77	0.77	0.8	0.78	0.79	0.8	0.78
Border Effect	**3.8**	**4.1**	**3.9**	**3.9**	**4.3**	**3.8**	**3.4**
ON: 78	ln(Rel.Prod.)=0.90 (29.54)		ln(Rel.Prices)=-7.95 (13.32)			ln(Gov.)=5.20 (8.15)	
	Not Adjacent=-0.71 (6.30)		ln(Distance)=-0.69 (11.40)				
Border	-1.23	-1.18	-1.16	-1.11	-1.31	-1.24	-1.21
t-value	(5.06)	(5.10)	(5.40)	(5.18)	(6.15)	(5.85)	(5.08)
R-squared	0.72	0.74	0.8	0.8	0.8	0.8	0.76
Border Effect	**3.4**	**3.3**	**3.2**	**3.0**	**3.7**	**3.5**	**3.4**
						(continued)	

Province / Observations	1997	1998	1999	2000	2001	2002	2003
QC: 78	ln(Rel.Prod.)=0.85 (25.91)		ln(Rel.Prices)=-8.44 (10.92)			ln(Gov.)=7.17 (10.55)	
	Not Adjacent=-0.83 (6.29)		ln(Distance)=-0.73 (10.31)				
Border	-1.51	-1.47	-1.43	-1.32	-1.50	-1.46	-1.44
t-value	(6.10)	(5.97)	(5.91)	(5.28)	(6.26)	(6.45)	(5.80)
R-squared	0.73	0.72	0.73	0.72	0.75	0.77	0.73
Border Effect	**4.5**	**4.3**	**4.2**	**3.7**	**4.5**	**4.3**	**4.2**
PE: 70	ln(Rel.Prod.)=0.77 (10.93)		ln(Rel.Prices)=-11.26 (6.58)			ln(Gov.)=2.25 (1.99)	
	Not Adjacent=-0.51 (1.29)		ln(Distance)=-0.96 (7.76)				
Border	-2.00	-1.74	-1.74	-1.71	-1.51	-1.67	-1.66
t-value	(4.87)	(4.34)	(3.76)	(4.24)	(3.74)	(4.31)	(4.49)
R-squared	0.72	0.73	0.64	0.67	0.67	0.71	0.72
Border Effect	**7.4**	**5.7**	**5.7**	**5.5**	**4.5**	**5.3**	**5.3**
NS: 78	ln(Rel.Prod.)=0.98 (16.22)		ln(Rel.Prices)=-10.55 (7.18)			ln(Gov.)=8.69 (7.98)	
	Not Adjacent=-0.87 (2.75)		ln(Distance)=-0.91 (8.70)				
Border	-2.34	-2.46	-2.19	-2.22	-2.62	-2.44	-2.51
t-value	(6.40)	(6.41)	(6.77)	(5.89)	(6.54)	(7.63)	(5.92)
R-squared	0.63	0.63	0.7	0.65	0.66	0.71	0.55
Border Effect	**10.4**	**11.7**	**8.9**	**9.2**	**13.7**	**11.5**	**12.3**
NB: 78	ln(Rel.Prod.)=0.73 (13.07)		ln(Rel.Prices)=-5.19 (4.30)			ln(Gov.)=3.67 (3.71)	
	No Adjacency=-1.13 (4.43)		ln(Distance)=-1.12 (10.89)				
Border	-1.18	-1.22	-1.22	-1.08	-1.04	-1.18	-1.30
t-value	(3.42)	(3.63)	(3.36)	(3.41)	(3.14)	(3.50)	(3.56)
R-squared	0.66	0.68	0.63	0.65	0.63	0.64	0.61
Border Effect	**3.3**	**3.4**	**3.4**	**2.9**	**2.8**	**3.3**	**3.7**
NF: 69	ln(Rel.Prod.)=0.34 (3.85)		ln(Rel.Prices)=-12.9 (5.84)			ln(Gov.)=-2.09 (1.56)	
	No Adjacency=-1.16 (2.52)		ln(Distance)=-0.74 (3.24)				
Border	-2.42	-2.27	-2.42	-2.74	-2.81	-2.50	-3.02
t-value	(4.21)	(3.98)	(5.03)	(4.61)	(5.03)	(4.77)	(4.87)
R-squared	0.41	0.41	0.49	0.34	0.41	0.46	0.36
Border Effect	**11.2**	**9.7**	**11.2**	**15.5**	**16.6**	**12.2**	**20.5**

t-values in parentheses
17 observations with 0 observed trade have been deleted

Some interesting effects occur in some provinces for variables other than border effects in this estimation. Non-adjacency is not significant for Alberta, and the effect of government is much smaller here and in Saskatchewan than elsewhere. Distance is a smaller factor for British Columbia, Quebec (both home to oceanic ports) and Ontario (very large trade in auto parts with Michigan may be a contributing factor). And in Newfoundland, the coefficient of the government share is negative, though insignificant (no adequate explanation can be provided at this time).

Next, following Anderson & Smith (1999) who first emphasized that the effect of the border might depend on the direction of trade, we modify our dataset in order to be able to take this into account. We break up our dataset into ten province-specific parts, which allows us to distinguish between individual interprovincial exports and imports in these datasets. Then we separate our border dummy into two dummies, for example ABM=1 for interprovincial imports by Alberta and ABX=1 for interprovincial exports by Alberta. Further, we define ABXUS=1 for Alberta's exports to the United States. In this setting, imports from U.S. are the baseline and every other type of trade is picked up by its own dummy variable. Therefore, our border for imports is the coefficient on ABM which directly indicates Alberta's propensity to import from other provinces over the U.S., and our border for exports is the difference between the coefficients on ABX and ABXUS. As usual, estimated border effects are the exponents of the absolute values of these estimated coefficients. We present the results of this estimation for the year 1997 and the year 2003 to save space, and yet obtain some idea of the time path of the import and export border effects for the provinces.

Table 9 shows the results of this exercise. It first confirms what we already know: in a year-to-year setting, border effect for Canada remained stable at around 5 between 1997 and 2003. But the surprising result is that in 1997 the border effect for imports was 10.9, five times the effect for exports (2.2); perhaps equally surprising is the growth of that difference to an order of magnitude by 2003 (16.8 for imports vs. 1.5 for exports, but resulting in the same average effect of 5). Put simply, this tells us that Canada as a whole has little aversion with regards to *exporting* to the United States, and has become more willing to do so between 1997 and 2003, to the degree that interprovincial exports are only 50% more attractive than exports to the U.S. But it is on the import side that the border effects truly matter: Canada is relatively very unwilling to import from the United States. A Canadian province was 10.9 times more likely to import from another province than from the U.S. in 1997, and this aversion has grown to 16.8 by 2003. It is no exaggeration to say that at present, nearly the whole border effect between the two countries is due to the import effect on the Canadian side.

Table 9. Border Coefficients for Exports and Imports, 1997 and 2003

1997			**Border for**	**Border for**	
Province	**Border**	**R-squared**	**Exports**	**Imports**	**R-squared**
British Columbia	-1.24 (5.5)	0.69	-0.28 (7.8)	-2.18 (7.4)	0.75
Alberta	-1.10 (3.9)	0.67	-1.20 (9.0)	-1.85 (5.1)	0.71
Saskatchewan	-1.27 (4.1)	0.67	-0.90 (8.7)	-1.92 (4.5)	0.70
Manitoba	-1.34 (6.1)	0.77	-0.87 (6.9)	-1.80 (6.1)	0.80
Ontario	-1.23 (5.1)	0.72	-0.96 (4.7)	-1.5 (4.6)	0.76
Quebec	-1.51 (6.1)	0.73	-1.01 (6.2)	-1.9 (5.7)	0.77
Prince Edward I.	-2.00 (4.9)	0.72	-0.69 (2.6)	-3.37 (5.8)	0.74
Nova Scotia	-2.34 (6.4)	0.63	-1.00 (5.0)	-3.73 (7.4)	0.67
New Brunswick	-1.18 (3.4)	0.66	-0.62 (1.8)	-1.73 (3.5)	0.66
Newfoundland	-2.42 (4.2)	0.41	0.36 (5.4)	-5.00 (6.7)	0.53
Canada	**-1.60 (11.0)**	**0.65**	**-0.80 (5.2)**	**-2.39 (15.3)**	**0.65**
Implied Border Effect, Canada	**5.0**		**2.2**	**10.9**	

2003			**Border for**	**Border for**	
Province	**Border**	**R-squared**	**Exports**	**Imports**	**R-squared**
British Columbia	-1.50 (6.8)	0.72	-0.30 (10.1)	-2.69 (9.3)	0.77
Alberta	-1.01 (2.5)	0.27	-0.64 (9.7)	-2.03 (5.0)	0.66
Saskatchewan	-1.28 (4.0)	0.63	-0.75 (9.4)	-1.98 (5.2)	0.74
Manitoba	-1.23 (5.9)	0.78	-0.46 (7.3)	-2.01 (7.0)	0.80
Ontario	-1.21 (5.1)	0.76	-0.41 (6.3)	-2.03 (6.3)	0.79
Quebec	-1.44 (5.8)	0.73	-0.46 (7.6)	-2.36 (7.11)	0.78
Prince Edward I.	-1.66 (4.5)	0.72	-0.07 (2.9)	-3.41 (6.7)	0.75
Nova Scotia	-2.51 (5.9)	0.55	-0.49 (8.0)	-4.58 (9.1)	0.71
New Brunswick	-1.30 (3.6)	0.61	-0.27 (3.3)	-2.31 (4.6)	0.64
Newfoundland	-3.02 (4.9)	0.36	0.16 (8.0)	-5.82 (7.4)	0.52
Canada	**-1.63 (9.4)**	**0.50**	**-0.42 (2.5)**	**-2.82 (16.7)**	**0.59**
Implied Border Effect, Canada	**5.1**		**1.5**	**16.8**	

t-values in parentheses
17 observations with 0 observed trade have been deleted

Provincial results confirm and extend these findings. Newfoundland is unique among Canadian provinces in that it prefers exporting to the U.S. than to other Canadian provinces; however its extreme unwillingness to import from the U.S. makes its average border effect the largest among the provinces. Other export-friendly provinces include Prince Edward Island, British Columbia and New Brunswick – but the rest are not very far behind, either. Aside from the Atlantic provinces, there is a remarkable uniformity of border dummy coefficients across other provinces: roughly -0.5 for exports and between 2 and 2.6 for imports; this translates into 1.6 export effect and 7 to 13 import effect.

What could be the explanation for such a strong result? Let us look at the overall

Table 10. Aggregates of Canadian Merchandise Trade, 1997-2003

$M, CAN	1997	1998	1999	2000	2001	2002	2003
Canadian Total Exports to U.S.	243,888	269,909	308,076	359,289	351,751	345,366	326,700
% growth since 1997	-	11%	26%	47%	44%	42%	34%
Canadian Total Imports from U.S.	184,414	203,578	215,575	229,660	218,290	218,497	203,803
% growth since 1997	-	10%	17%	25%	18%	18%	11%
Canadian Total Imports from China	6,341	7,651	8,951	11,294	12,724	16,004	18,581
% growth since 1997	-	21%	41%	78%	101%	152%	193%
Canadian Total Imports from Mexico	7,022	7,682	9,536	12,060	12,123	12,744	12,190
% growth since 1997	-	9%	36%	72%	73%	81%	74%
Canadian Total Imports from Korea	2,838	3,312	3,572	5,282	4,605	4,865	5,108
% growth since 1997	-	17%	26%	86%	62%	71%	80%
Canadian Interprovincial Trade	1,011,079	1,046,572	1,138,020	1,293,130	1,288,630	1,307,980	1,321,708
% growth since 1997	-	4%	13%	28%	27%	29%	31%

Canadian merchandise trade data between 1997 and 2003 (Table 10). We see that both the Canadian interprovincial trade and Canadian exports to the U.S. have grown roughly by a third during this time period, though exports to the U.S. have grown a little faster. Meanwhile, Canadian imports from the U.S. have grown only by 10%. Lastly, Canadian imports from its major "low-cost labour" trading partners have grown much faster – almost doubled for Mexico and South Korea, and tripled for China. At this aggregate level, the conclusions of Table 9 seem much more believable. Canadian exports to U.S. are growing faster than Canadian interprovincial trade, slightly decreasing the observed border effect for exports. Imports from U.S. are growing much slower than inteprovincial trade, thus increasing the observed border effect; and the shortfall in imports is increasingly being made up by import substitution from the developing economies such as China, Mexico and South Korea.

This raises a question about the border effects methodology employed. While in 1997 the effects of this import substitution were negligible, they were no longer such in 2003. A growth in attractiveness of imports from China (whether due to preferences, prices or other effects) must necessarily reduce the imports from the United States; but it is questionable whether translating this substitution effect into a higher border effect, as the current approach does, is entirely legitimate. A more proper assessment of the border effect would seem to be the comparison of Canadian imports from the United States to all Canadian trade, including imports from other major trading partners. Thus, while the Head/Mayer simplification in our model obviates the need for remoteness variables in the specification, a more extended specification might be necessary to produce an unbiased estimate of the border effect between the two countries. We believe that further research in this direction will produce an even better measure of integration as represented by the border effect.

Although the above point is believed to be the major reason for the drastic difference between import and export border effects, the quality of data could certainly contribute somewhat. The extremely high resistance of the three Atlantic provinces (Newfoundland, Nova Scotia and Prince Edward Island) to imports from the U.S. may indicate that the goods they import are wrongly attributed to the provinces through which they arrive, and not to their true origin in the United States. This effect is unlikely to be crucial as the elimination of these provinces does not change the main conclusions, but better data on the origin of goods could certainly help to correct this bias.

6 Conclusions and Further Research

This paper has developed a regional model of trade in differentiated goods and applied it to the largest set of data ever used to estimate Canada-U.S. border effects. Taking advantage of this dataset, we are able to introduce several theoretically important variables overlooked in previous research, and estimate our specification with the use of time-series techniques. The model is robust and applicable to any set of regional data in the world; it bypasses the need for remoteness measures using the Head & Mayer simplification, and is the first theory-derived regional model to estimate Canada-U.S. border effects with the use of this technique.

We reach several interesting conclusions in the process. First, border effects between Canada and U.S. estimated from this regional model are much lower than suggested by previous research. Our preferred estimates show that border effects range between 2.2 in 1988 and 5.5 in 2003. We explain this result by our inclusion of tariffs into the estimated specification and the solid theoretical foundation that we have developed. Second, the time dynamics of the border effects seem to be very different from those previously described in the literature. By introducing fixed and interactive time effects, we show that insofar as border effects stand for the unexplained trade-reducing power of the Canada-U.S. border, they have grown significantly between 1988 and 2003. Third, we find that the shares of the national and regional governments in the regional economies of North America have a significant impact on the estimated border effects, and thus governments should be included as one of the explanatory factors in all future studies. Finally, we find that the overall Canada-U.S. border effect is largely import-driven, in the sense that Canadian provinces are quite willing to export to the U.S., but averse to importing from there. The resulting shortfall in imports is made up by importing from third countries. This is a strong demonstration of the fact that the border effects are not the same in the two directions, and should be estimated separately by future studies.

The above findings offer significant opportunities for further research, both into producing better estimates of border effects, and into interpreting these values. The effects of language as a proxy for social and cultural networks have not been made clear, which is due in our opinion to the largely monolingual environment of North America. A similar regional model might do better in Europe or elsewhere, pointing the way for better modeling of languages and networks that have an influence on cross-border trade. Also, variables other than language that proxy these networks well can add explanatory power and improve the specification.

The estimation procedure itself can crucially benefit from more and better data. A reliable intertemporal set of data on non-tariff barriers may be a key explanatory factor for the current border effects; it may indicate that the recent trade disputes between Canada and the U.S. are responsible for part of the increase in the border effect between the two countries. As there is a large increase in 2001 in our preferred estimates, it is hypothesized that the effect of the recent security measures imposed by the United States may also be partially responsible for the rising border effects in recent years.[13]

Measures of gross output by U.S. state, currently under development at the Bureau of Economic Analysis, can help produce more precise estimates. Inclusion of the

[13] Heightened scrutiny of immigration, tourism and trade may raise the cost of trade and discourage the formation of international trading networks.

United States Consumer Flow Survey data may be an interesting extension to the model, although time-series exercises will not be available in that case.

Also, while many changes have been made to the original McCallum (1995) methodology, its basic spirit remained intact until now. The core border effects methodology compares trade flows with a foreign country vis-à-vis internal trade benchmarks. We have shown above that this approach can be influenced by changes in the patterns of trade with third countries, and that it would be more proper to derive a single average border effect that takes into account trade with all major trading partners, with subsequent differentiation of this border effect into pairs of country-specific bilateral resistances to imports and exports.

Overall, McCallum's basic finding that national borders matter remains in force, with some qualifications. First, the power of the borders themselves is of course illusory; in reality, it is the very existence of nations and all their policies that is restricting trade. International trade is generally restricted by two types of factors: consumer preferences for domestic goods and higher costs of international trade as opposed to internal trade. These two are due in turn to several variables, which can be incorporated theoretically and used to explain border effects in the manner shown above. On the basis of findings of this paper and the previous literature, we believe that a full explanation for border effects is to be sought along this path.

In addition, as we reason that the borders are created and maintained by the enlightened self-interest of rational populations, the question of measuring their welfare effects seems to be associated with difficulties. In other words, if borders were welfare-decreasing on aggregate, they would disappear already – as they are slowly disappearing in Europe.

Lastly, we point out that border effects are much smaller than previously believed, but the truly surprising fact is that they have been growing in the recent years. Even though the overall progress of the world economy towards globalization is undeniable, this progress may not proceed in a straight line, and should not be taken for granted. Local reversals of this global trend may and will happen. Whether our findings are the premonition of a break in the continuously increasing trend of global trade growth since 1945, or a temporary phenomenon, only time can tell.

Appendix A

The Gravity Equation:

From History to Practice to Theory

The gravity equation is a widely used specification for econometric analysis of various flows between countries/regions. In international trade, gravity equations typically analyze merchandise trade flows between two or more countries. In this setting, they are distinguished for being highly effective in explaining variation in trade data and for their robustness in doing so.

The original idea behind the equation is due to Newton's gravity law, which proposed that the force of attraction between two objects *i* and *j*, *Fij*, is directly proportional to their masses, *Mi* and *Mj*, and inversely proportional to the squared distance *Dij* between them:

$$F_{ij} = G \frac{M_i M_j}{D_{ij}^2} , \tag{1}$$

with *G* being a gravitational constant.

With a slight change in notation, this specification was first applied, independently, by Tinbergen (1962) and Poyhonen (1963) to the analysis of trade flows between nations. Since that time, it has become a very popular method for explaining variation in bilateral trade.

The empirical gravity equation has been specified in many different ways in the literature. In its simplest form it is expressed as follows:

$$X_{ij} = A\frac{Y_i Y_j}{D_{ij}} , \quad (2)$$

where i and j are the two trading partners, X_{ij} is the flow of trade between them (sometimes the sum of exports and imports, and sometimes a flow in one direction), Y_i and Y_j – trading partners' "economic masses", usually specified as GDPs, D_{ij} – the "economic distance" between them, defined as the cost of transporting traded goods between the partners, and usually specified as the distance between their most important cities, and A is a vector of other variables that may influence trade flows further through their linking or dividing effect on the two trading partners.

Theoretically, all of the variables in the above equation could be free to take various powers; note that in the original Newton's Law, distance takes the power of two. In practice, through experience with gravity equation, the consensus in the literature is that the best fit is achieved under (2), where both GDPs and distances carry the power of one.

Thus the simplest gravity specification in international trade that can be estimated is the logged form of (2) with small letters representing the natural logs of the variables above:

$$x_{ij} = \beta_0 + \beta_1 y_i + \beta_2 y_j - \beta_3 d_{ij} + \beta_4 a + \varepsilon , \quad (3)$$

Both (2) and (3) imply that trade is expected to grow with the economic size of the partners and decrease with distance between them. The typical gravity equation may include several other variables in the a vector, such as estimates of alternative trading opportunities, squared distance or GDP terms, and various dummies for common language, trading bloc etc. One commonly used specification includes population as an additional measure of the country's economic size; this specification is typically referred to as augmented gravity equation (although the term augmented may also be used for any equation incorporating additional variables).

Overall, this simple equation is one of the most successful empirical specifications in international economics; the gravity model is robust and powerful, routinely explaining 80% and more variation in trade between countries. Besides international trade, gravitational attraction was successfully used to explain migration, tourism, foreign investment and other interactions between countries and regions.

Concerns were raised in the economic literature that the intuitive appeal of the gravity equation and its shorthand representation of the forces of supply and demand bypass formal economic theory. These concerns were first addressed by Anderson (1979) who derived the gravity equation formally from expenditure share equations with commodities distinguished by place of production.

This derivation goes as follows. Anderson assumes identical homothetic preferences across countries which produce commodities differentiated by place of origin. In the simplest possible case, each country is completely specialized, i.e. produces one good only. Due to simple Cobb-Douglas preferences everywhere, the fraction of income spent on the product of country i is identical in all countries, and denoted b_i. Choosing units so that prices are equal to unity, it can be stated that the value of imports of good i by country j is:

$$M_{ij} = b_i Y_j , \tag{4}$$

where Y_j is income in country j. Meanwhile, the income of country i must equal its sales:

$$Y_i = b_i(\Sigma_j Y_j) \tag{5}$$

Substituting for b_i from (5) into (4), we obtain:

$$M_{ij} = \frac{Y_i Y_j}{\Sigma Y_j} \qquad (6)$$

This is the simplest form of gravity equation without tariffs or transport costs. In a pure cross-section estimate, the denominator is simply an irrelevant scale term; thus (6) simply states that imports are directly proportional to the GDPs of the importer and exporter.

The subsequent introduction of the non-traded goods sector, many goods and transportation costs result in the following form of the theory-implied gravity equation:

$$M_{ij} = \frac{m_i \phi_i Y_i \phi_j Y_j}{\Sigma_j \phi_j Y_j} \frac{1}{f(d_{ij})} \left[\Sigma_j \frac{\phi_j Y_j}{\Sigma_j \phi_j Y_j} \frac{1}{f(d_{ij})} \right]^{-1} U_{ij}, \qquad (7)$$

where m_i is the scale factor, ϕ_i and ϕ_j are expenditure shares on traded goods, $f(d_{ij})$ is the specification of transportation costs as an increasing function of distance and the same across commodities, and U_{ij} is a log-normal disturbance with an expectation of 0.

This formulation is considered by the author to be the best case one can make theoretically for the gravity equation as it is usually estimated empirically. There are still three significant differences between the latter and what (7) implies: (7) is an aggregate equation, and not commodity-specific; $f(d_{ij})$ is not necessarily log-linear; and finally, the term in square brackets is missing from the usual formulation of the gravity equation. These are the remoteness terms that denote the relative distance between the importer and all of his trading partners; their importance is underscored in further research, in particular Anderson and van Wincoop (2001).

The specification developed in chapter 4 takes into account the points made above. It is an aggregate and not a commodity-specific model that we estimate. Experiments with different distance specifications indicate that the best explanatory power is achieved when distance is included log-linearly without powers. Finally, the need for remoteness terms is obviated in our specification by dividing trade flows through by internal trade flows.

Bergstrand (1985) presents a general equilibrium model of world trade with N countries, assuming one factor of production in each. A gravity equation arises from this system after a few simplifying assumptions. Assuming small open economies and identical utility and production functions, his set of equilibrium equations can be simplified to:

$$PX_{ij} = Y_i^{(\sigma-1)/(\gamma+\sigma)} Y_j^{(\gamma+1)/(\gamma+\sigma)} C_{ij}^{-\sigma(\gamma+1)/(\gamma+\sigma)} T_{ij}^{-\sigma(\gamma+1)/(\gamma+\sigma)} E_{ij}^{\sigma(\gamma+1)/(\gamma+\sigma)} *$$
$$* (\Sigma' P_{ik}^{1+\gamma})^{-(\sigma-1)(\gamma-\eta)/(1+\gamma)(\gamma+\sigma)} (\Sigma'' P'^{1-\sigma}_{kj})^{(\gamma+1)(\sigma-\mu)/(1-\sigma)(\gamma+\sigma)} *$$
$$* \left[(\Sigma' P_{ik}^{1+\gamma})^{(1+\eta)/(1+\gamma)} + P_{ii}^{1+\eta}\right]^{-(\sigma-1)/(\gamma+\sigma)} \left[(\Sigma'' P'^{1-\sigma}_{kj})^{(1-\mu)/(1-\sigma)} + P_{jj}^{1-\mu}\right]^{-(\gamma+1)/(\gamma+\sigma)}, \tag{8}$$

where PX_{ij} is the value of trade flow of good X at price P from i to j, Y are expenditures, μ is the constant elasticity of substitution (CES) between domestic and importable goods for all countries, σ is the CES among importable goods in all countries, η is the constant elasticity of transformation (CET) between home and foreign production, γ is the CET for production among export markets, P_{kj} is the k-currency price of k's product sold in j's market, $P'_{kj} = P_{kj}T_{kj}C_{kj}/E_{kj}$, T_{kj} is j's tariff rate on k's product plus unity, C_{kj} is the transport cost factor to ship k's product to j, and E_{kj} is the spot value of j's currency in terms of k's currency, Σ' is the summation over $k = 1, \ldots, N$ excluding i, Σ'' is the summation over $k = 1, \ldots, N$ excluding j.

This "generalized" gravity equation can be transformed further into a more simplified form, similar to that used empirically, if four additional assumptions are made. These are: perfect substitutability of goods, perfect arbitrage, zero tariffs and zero transport costs. The resulting equation is:

$$PX_{ij} = (1/2)Y_i^{1/2}Y_j^{1/2} \tag{9}$$

Overall, the generalized version (8) is considered more appropriate than (3) due to the restrictiveness of the four additional assumptions that lead to (9). The main point made by Bergstrand is that a gravity equation similar to (3) can be derived from his model, but if the aggregate trade flows are differentiated by place of origin, then (3) misspecifies the gravity equation by omitting, in particular, certain price variables. Our specification in chapter 4 takes these price variables into account.

Lastly, let us examine the contribution of Deardorff (1998) which derives the gravity equation from the Heckscher-Ohlin model under two differing sets of assumptions. First, under frictionless trade and homogeneous products, producers and consumers are perfectly indifferent between trading partners and choose them by random allocation. In this case, expected trade flows will correspond exactly to the gravity equation (6) if preferences are identical and homothetic, through a chain of reasoning similar to Anderson (1979). Under arbitrary preferences, it is still possible to get a similar result as long as exporter production shares and importer consumptions shares are not correlated. In essence, the gravity equation (6) then describes the average state of affairs in this market; if one country tends to "overproduce" the good that another country "overconsumes", then the gravity equation will underpredict trade, and vice versa.

Of more interest are the results in the case of impeded trade. Strictly positive barriers to trade, such as transportation costs, are defined for every good. Also, and crucially, every country produces different goods, implying full specialization as defined within the Heckscher-Ohlin model. Due to positive barriers to trade, no countries that achieve factor price equalization (FPE) can actually trade with each other, because their f.o.b. output prices are the same. This leads in turn to the conclusion that only one country will export any particular good to the world markets, taken further by the assumption that this good will only be produced in that one country. These goods are considered imperfect substitutes, and transportation costs are assumed to be of "iceberg" form, with a fraction of the good shipped between countries "melting" in transit.

Under identical Cobb-Douglas preferences, consumers in each country will spend a fixed share, β_i, of their income on goods from country i. Country's i income Y_i is:

$$Y_i = p_i x_i = \Sigma_j \beta_i Y_j = \beta_i Y^w , \qquad (10)$$

where Y^w is world production. Hence $\beta_i = Y_i/Y_w$. If trade is valued on f.o.b. basis - that is, exclusive of transport costs t_{ij}, it can be expressed as:

$$T_{ij}^{fob} = T_{ij}^{cif}/t_{ij} = \frac{\beta_i Y_j}{t_{ij}} = \frac{Y_i Y_j}{t_{ij} Y^w} , \qquad (11)$$

which is a familiar form of the basic gravity equation, inclusive of distance insofar as transportation costs are a simple function of distance.

Finally, assuming CES preferences instead of Cobb-Douglas, let consumers in country j maximize their CES utility function:

$$U^{j}=\left(\Sigma_{i}\beta_{i}c_{ij}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \quad , \tag{12}$$

where $\sigma>0$ is the constant elasticity of substitution between any pair of countries' products. Maximizing this under c.i.f. prices of $t_{ij}p_i$, j's consumers constrained by $Y_j = p_j x_j$ will obtain the optimal consumption c_{ij} as:

$$c_{ij}=\frac{1}{t_{ij}p_{i}}Y_{j}\beta_{i}\left(\frac{t_{ij}p_{i}}{p_{j}^{I}}\right)^{1-\sigma} \quad , \tag{13}$$

where $p_{j}^{I}=(\Sigma_{i}\beta_{i}t_{ij}^{1-\sigma}p_{i}^{1-\sigma})^{1/(1-\sigma)}$ represents the CES price index in country j.

Hence, the f.o.b. value of exports of country i to country j is:

$$T_{ij}^{fob}=\frac{1}{t_{ij}}Y_{j}\beta_{i}\left(\frac{t_{ij}p_{i}}{p_{j}^{I}}\right)^{1-\sigma} \tag{14}$$

Defining θ_i as country's i share of world income, relating it to β_i and solving yields the final version of the gravity equation under CES in H-O model:

$$T_{ij}^{fob}=\frac{Y_{i}Y_{j}}{Y^{w}}\frac{1}{t_{ij}}\left[\frac{\left(\frac{t_{ij}}{p_{j}^{I}}\right)^{1-\sigma}}{\Sigma_{h}\theta_{h}\left(\frac{t_{ih}}{p_{h}^{I}}\right)^{1-\sigma}}\right] \quad , \tag{15}$$

which is a familiar result: trade is proportional to partners' incomes, inversely proportional to transportation costs that are a function of distance, and is affected by the remoteness variables that describe its relative distance to its trading partners.

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