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ABSTRACT

We discuss biases in preferences and their trade effects in terms of impacts on non-neutral trade flows motivated by recent literature on both home bias and the border effect. These terms take on multiple definitions in the literature and are often used interchangeably even though they differ. The border effect refers to a higher proclivity to trade behind rather than across national borders and is usually defined by the coefficients of regional dummies from an estimated gravity model. It can be present both in data and in counterfactual model solutions. Sometimes the reduced form of the gravity model used is asserted to reflect an Armington type model. For the border effect to occur as a model outcome, a structural model with at least 2 home regions and 1 country abroad is needed. In contrast to current literature, we offer a characterization of various forms of preference bias in trade models and measures of their associated trade effects based on a concept we term trade neutrality. These effects go beyond conventional border effects, and can be both across and within borders. Home bias is typically specified as an Armington preference for domestic over comparable foreign products in a trade model where goods are heterogeneous across countries. It is reflected in both model structure and parameterization, but defined in several different ways in the literature. We assess the contribution of each form of bias to the set of possible trade effects using a calibrated model with 3 Canadian regions, the U.S., and the rest of the world using 2001 data. We also evaluate how much of the conventional border effect is accounted for when model biases are modified in various ways.

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1. Introduction

The last 10 years have yielded a large body of research on two seemingly closely related issues: the border effect and home bias. The border effect is a feature that can be present either in observed data or a counterfactual model solution and is usually associated with McCallum's (1995) paper in which he used the gravity model applied to both the international and interprovincial trade of Canadian provinces to show that even correcting for distance there is still a large effect of the Canadian border on Canada-US trade patterns. This is true even if there are low tariffs in both countries. McCallum's objective was to counter earlier claims in the literature that due to postwar economic integration in the OECD borders had effectively disappeared in terms of their impacts on behavior.

Home bias has a longer history and can refer to features of both model specification and parameterization. It is implicit in the numerical general equilibrium models of the 1980s (see Whalley (1985)) which in turn used Armington's (1969) formulation of product differentiation by country. In older literature this model structure was used to capture less than full flow through of changes in world prices onto domestic prices, and hence smaller impacts of trade liberalization and other counterfactuals on trade volumes than would occur in a comparable homogeneous goods trade model. In its more recent guise, home bias is a term often associated with Trefler's (1995) paper on missing trade; the difference between actual trade and that predicted by a Hecksher-Ohlin-Vanek (HOV) model using homogeneous goods. This he attributes to consumer preference in favor of domestically produced goods in the same sense as Armington, but unlike Armington his characterization implies more not less trade than in a heterogeneous goods trade model due to home bias.

Neither of these two terms, home bias or border effect, is clearly or uniformly defined in the literature. Multiple constructs are used to represent home bias by various authors (Treffler, 1995; Bloningen and Wilson, 1999; Head and Ries, 2001; Brulhart and Trionfetti, 2001; Hillberry and

Hummels, 2002). Sometimes it is assumed to be reflected in share parameters that weights the import good relative to the domestic good in Armington type trade model (Blonigen and Wilson, 1999); sometimes in relative share parameters across country Armington functions in a 2 country models (Head and Ries, 2001); sometimes through an added term in preferences which gives utility from consumption of a domestic good over total consumption (Brulhart and Trionfetti, 2001); sometimes in an additional term in linear demands (Treffler, 1995); sometimes as a feature of data (Hillberry and Hummels, 2002). The border effect has less ambiguity of definition but can refer instead to either data or model outcomes. To generate it as a model outcome seemingly implies some form of regional bias among regionally differentiated products which is different from conventional home bias as a preference for domestic over foreign goods. At a minimum, for the border effect to occur it seems to call for a structural model with 2 domestic regions and 1 foreign country. If conventional home bias implies preferences that operate in favor of domestic goods then one does not need a model with regional structure. If both home and regional biases are present they seemingly operate separately.

The border effect is usually measured by a multiplier derived from a gravity model regression. The estimated coefficient for a regional dummy can be used to calculate the higher probability of trade occurring between regions in a country rather than across national borders. Other authors measure the border effect in different ways. Head and Ries (2001), for instance, measure the border effect as $\sqrt{\frac{x}{1-x}.\frac{x^*}{1-x^*}}$, where x and x^* are the shares of home and foreign produced goods in expenditure.

These two terms border effect and home bias also do not refer to the same thing, despite several places in the literature where the terms are used interchangeably. Obstfeld and Rogoff (2000), for instance, refer to the "McCallum Home Bias in Trade" puzzle as one of the 6 leading puzzles in modern international macroeconomics[1], and to recent other literature (Wei, 1996; Evans, 2003) as testing for

[1] Obstfeld and Rogoff (2000) also state that "Samuelson (1954) argues that the existence of an international transfer problem depends critically on whether there is a home bias in consumption; and he showed explicitly how a home bias could be derived from transport costs", when in fact Samuelson seemingly never used or discussed the term home bias.

home bias in other countries using McCallum's procedures (which relate to the border effect rather than home bias). Anderson and Van Wincoop (2003) claim to show how McCallum's estimates of the border effect exaggerate home bias. Other authors claim that home bias occurs because of the border effect.

This paper tries to clarify this confusing use of terminology. We argue that multiple biases can operate in Armington trade models with multiple domestic regions and 2 or more countries and associated trade effects can occur either across or within borders. These biases can be separated out one from another (such as a conventional home bias or a regional bias) in generating any trade (or border) effect the model yields as a solution. All Armington models inevitably imply bias (or difference) in behavior relative to a comparable homogeneous goods model since changes in world prices (or a tariff) are not fully transmitted to domestic prices and trade impacts are smaller than in the homogeneous goods case. In the form of Armington trade model at issue in the border effect discussion there are multiple levels of nesting, and hence more than one type of model bias can be present.

We show how one can use numerical simulation methods to assess the contribution of each model bias (or subset of them) to the observed trade effect. Unlike earlier literature which removes or adds home bias by directly changing preferences or other parameters, our procedure for assessing trade biases first involves model calibration both to an observed equilibrium in which trade (or border) effects are present, and to a constructed synthetic equilibrium in which trade or border effects are absent. This we term a trade neutral equilibrium. The influences of model biases are then assessed by introducing portions of the calibrated model parameterization generated using observed data into the model parameterization supporting the data with no trade effects. These procedures, we argue, are more appealing than those used far in the literature.

The remainder of the paper is organized as follows. Section 2 provides a discussion of home bias

He did discuss how differential income elasticities in a homogeneous goods trade model could cause international transfers to generate terms of trade effects, which is different.

and border effect and presents our measures of trade (or border) effects and biases. We also discuss how to represent and remove biases in Armington trade models using the trade neutrality concept. Section 3 describes the setup of a numerical model that we use to assessing the contributions of varying biases to the trade (or border) effects. Data issues and parameterizations are also discussed in this section. Results from the use of numerical simulation methods to assess the contribution of each (or subset of) model bias to the observed trade effects are presented in section 4. Section 5 concludes.

2. The Border Effect, Home Bias and Trade Neutrality in Armington Trade Models

In McCallum (1995) and subsequent gravity model literature the border effect is calculated using the regression coefficient of a border dummy in the gravity equation. McCallum (1995) specifies an estimating equation for x_{ij} as the log of shipments of goods from region *i* to region *j* of the form

$$x_{ij} = a + by_i + cy_j + d\text{dist}_{ij} + e\text{DUMMY}_{\text{ij}} + u_{ij} \tag{1}$$

where y_j is the log of gross domestic product in *j*, dist_{ij} is the log of distance between region *i* and region *j*, DUMMY_{ij} is a dummy variable which is 1 if *i* and region *j* are regions within the country and 0 otherwise, and u_{ij} is an error term[2].

McCallum uses data for incomes for 10 Canadian provinces, and their shipments with the largest 30 U.S. states for 1988, along with data on the bilateral trade flows between Canadian provinces to estimate (1). He then compares actual trade to predicted borderless trade with the dummy removed. The gravity model predicts that, on average combined, Canadian internal and international trade should be overwhelmingly North-South. The presence of the Canada-U.S. border results in trade between two

[2] Although exports are usually the dependent variable in gravity models, the gravity model can also be applied to imports and combined bilateral trade. A key assumption using the gravity model to estimate border effects in this way is symmetry; that exports by region *i* to region *j* equal exports by region *j* to *i*. If the symmetry assumption is not met, the border effect from a gravity model on exports will differ from the border effect in terms of imports.

Canadian provinces which, on average, is 20 times larger than trade between an average province and an average state. This multiplier is referred to as the border effect in McCallum's paper and in subsequent studies. By way of example, his results imply that British Columbia's exports to Texas should be 50% larger in a borderless world than their exports to Ontario, while in the data they are 1/11th of these. McCallum provides no structural behavioral model to underpin his regression, and the term border effect is defined only in terms of the regression coefficient on the regional dummy.

Later studies using the gravity model, such as Helliwell (1998), suggest that the Canada-U.S. border effect has been decreasing following the implementation of the U.S.-Canada FTA. However, almost all studies support the position that the Canada-U.S. border effect is still strong (Helliwell, 1996 and 1998; Anderson and Smith, 1999; Anderson and van Wincoop, 2003; Hillberry, 2002; Balistreri and Hillberry, 2005; Wall, 2000). Engel and Rogers (1996) find similar border effects by examining the variation of the prices of similar goods in different U.S. and Canadian cities. A number of studies also suggest that there is a similar border effect within the EU (Head and Mayer, 2002), within the OECD (Wei, 1996; Evans, 2003) and even within the U.S. comparing across and within state shipment data (Wolf, 2000; Hillberry and Hummels, 2003).

The theoretical foundations of the gravity models used in this literature are based on simple Armington trade models using CES functions and are discussed in Anderson (1979), Bergstrand (1985, 1989) and Deardorff (1995). Anderson and van Wincoop (2003) relate their discussion of Armington and gravity models to the border effect, showing that McCallum's regression misses relative price effects involving third countries as bilateral border effects are reduced. With these included, the estimated border effect calculated using McCallum's regressions is considerably smaller[3].

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[3] Other studies indicate that resource endowments, product characteristics, and substitution elasticities between home and foreign goods can also affect the size of the border effect (Obstfeld and Rogoff, 2000; Wolf, 2000; Fairfield, 2001; Hillberry, 2002). Hillberry (2002) shows that the Canada-U.S. border effect varies across commodities and after

Home bias in trade literature is usually taken to refer to model features and parameterizations reflected in bias in preferences in favor of home produced over foreign produced goods. Home bias is generally not seen as something present in data or a model solution, but instead reflected in model characteristics. The literature contains a variety of characterizations of home bias. Trelfler (1995) appeals to the term to econometrically account for missing trade relative to that which would be predicted by an econometrically estimated HOV homogeneous goods trade model. He assumes linear demands for goods which are not based on utility maximizing behavior and uses the term home bias to justify additional linear demand based on the difference between world and domestic production. Blonigen and Wilson (1999), instead, discuss home bias solely in terms of preferences in the home country and provide a measure of home bias that links the elasticity of substitution and the estimated intercept from Armington elasticity regressions. They claim home bias in their sense is removed by setting equal share parameters on domestic and foreign goods. Head and Ries (2001), in contrast, define home bias only in terms of the share parameters of lower level CES preference functions in a nesting structure in a 2 country trade model, and this involves the share parameters in both countries. Their approach to removing home bias is to fix the relative share parameters for consumption over domestic and foreign goods across the 2 countries in the model. Brulhart and Trionfetti (2001) go further and modify conventional Armington preferences to capture home bias by including not only consumption of each good but also the amount of home products consumed as an additional argument in the home country utility function. They use Cobb-Douglas preferences and weights on total and home consumption which sum to one for one good for which there is assumed to be home bias. Home bias in this characterization is removed when the weight on home consumption is zero. Finally, in Hillberry and Hummels (2002) home bias is defined in terms of trade flows rather than model characteristics. Home

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controlling for the industry location effects the border effect is reduced to 5.9 from 20.9. In his study of the border effect within OECD, Evans (2003) also finds the size of border effect varies across different industries. Efforts have also been made to improve the distance measurement used in gravity models, such as Wei (1996) in his study of the OECD border effect. Some studies also suggest that the large border effect may not cause substantial welfare distortion, since the border effect be caused by non-distortionary factors, such as resource endowments, transaction costs and product characteristics (Evans, 2003; Fairfield, 2001).

bias is present in trade flow data when trade deviates from that which would solely reflect relative country size. Home bias under this approach can be measured directly from data with no appeal to a model.

These alternative definitions of home bias unfortunately confuse the relationship between home bias and the border effect. With so many characterizations, it is not clear either how to measure or even interpret home bias from the literature. How it links to the border effect is also not clear although much of the literature either proceeds as if the two terms are either synonymous or, if not, are closely linked.

In terms of a direct characterization of the term in terms of preferences, if we consider a commodity X which in reality has no physical differences across countries of source, but assume that consumers in some way perceive there to be differences and these appear in consumer preferences, one approach is first to characterize the absence of home bias as no discrimination in preferences based on domestic and foreign sources of supply. In two-good space, if we subscript X by domestic (D) and foreign (F) sources, an absence of home bias is associated with consumers equally valuing alternative but equivalent combinations of X_D and X_F in utility terms. X_D and X_F are thus perfect substitutes in this case. In Figure 1, this corresponds to preferences over X_D and X_F which yield linear indifference surfaces with slope -1 as in Panel A. This is drawn as the indifference curve with utility $\overline{U}$.

If instead home bias is present, consumers will give different utility evaluations to alternative combinations of domestic and foreign consumption along this surface even though in reality the two sources of supply yield identical goods. As drawn in Figure 1 Panel B, we consider a line with slope of -1which now yields a tangency at A to an indifference surface yielding utility $\overline{\overline{U}}$. If we move to equal consumption of home and foreign goods on this line at point B, a utility loss is involved. As such, the home bias of consumption at point A measured in utility terms is the difference between utility level $\overline{\overline{U}}$ and $\hat{U}$. To remove home bias from these preferences in the CES case suggests allowing CES share parameters to become uniform (0.5 for each of X_D and X_F in this case) and the elasticity of substitution to approach infinity so that X_D and X_F are perfect substitutes in preferences.

Unfortunately, such a modification to preferences will not eliminate the border effects as a model outcome in an Armington model. As this incorporates heterogeneity of products by country of origin when such a model is solved with uniform share parameters, unless the two countries are of equal size trade will still be biased in a way which is reflected in a border effect. Setting share parameters to reflect relative country size is also not sufficient to eliminate border effects in model outcomes unless allowance is made for the effects of the elasticity of substitution on share parameters.

Instead of directly setting share parameters to values which researchers assert will remove any element of trade or border effect in model generated results, we adopt an approach of first constructing a model parameterization consistent with the absence of such effects. We then assess the departures in model preferences implied by the model parameterization generated by calibration to observed data.

We do this by not only calibrating a trade model to observed data in which trade (or border) effects are present, but also by calibrating to a synthetic (generated) computable equilibrium in which trade (or border) effects are absent. This we term a trade neutral equilibrium and we characterize this in the next section. This procedure yields two model parameterizations, one consistent with observed data, and the other consistent with an absence of trade (or border) effects. We can then introduce portions of the parameterization consistent with the observed equilibrium into the parameterization consistent with the trade effect absent and assess the effect on measures of trade or border effects. The details of these procedures are set out in the next section.

Figure 1

Characterizing Home Bias

Panel A — Absence of Home Bias

Panel B — Presence of Home Bias

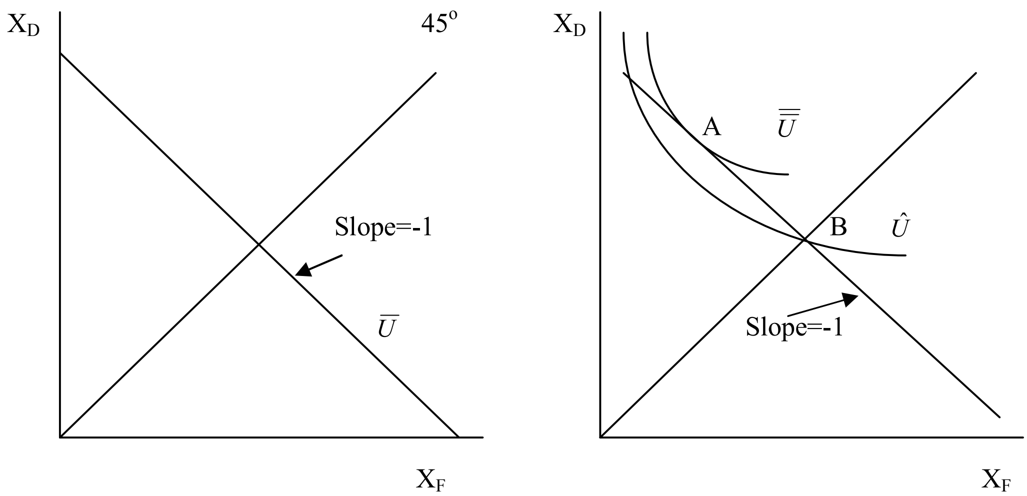


Figure 2

Nesting Structure and Biases in Multi-Region Armington Trade Models

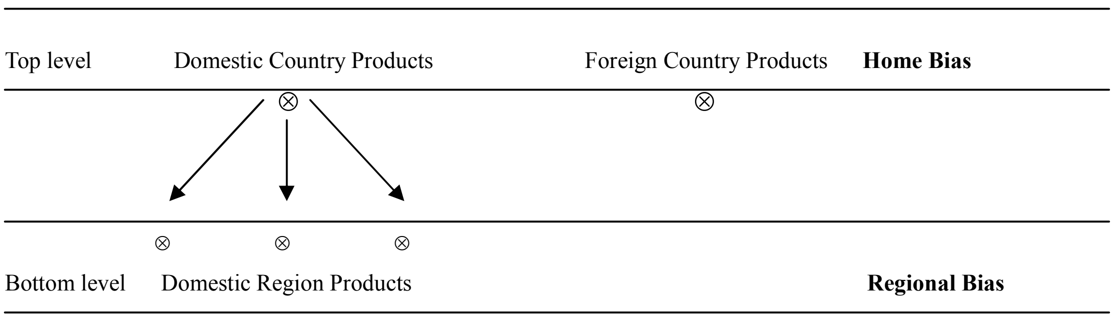


Figure 2 schematically sets out the structure of nesting of Armington type functions which we employ in the modeling approach used in the next section. In this particular model structure, conventional home bias relates to top level heterogeneity and regional bias to lower level heterogeneity. The border effect is reflected in a model outcome in which there are larger volumes of interregional compared to international trade than differences in the size of countries and regions alone would imply. Model biases can be weakened or removed either separately or in total, and as they change the border effect present in data relative to the outcomes of the model will change.

Assessing the contribution of various model biases to model outcomes (in terms of interregional and international trade volumes) involves comparing results across similar models where varying forms of bias (by level and by country) are replaced by elements of a model parameterization generated by calibration to a model in which there is an absence of trade effects. Experiments can be conducted for portion of the biases in a model (say between products across regions but not across countries), or for all the biases in the model. Conventional home bias seemingly refers to product heterogeneity across countries. The border effect as discussed in existing literature is a model outcome relating to regional trade flows and involves product heterogeneity across regions as well as across countries.

We explore the contribution of various model biases (conventional home bias, regional biases) to model generated trade effects by measuring trade effects relative to a reference point. This, we suggest, is best done by using a model parameterization consistent with a trade neutral equilibrium rather than using particular settings of model parameters as current literature attempts. Unlike McCallum, we use an explicit structural model rather than a gravity equation model, and so we calculate the trade effect to biases using a different method from that followed in gravity model regressions, even though the economic logic behind our measurement and the gravity regression coefficient method are the same. We measure trade effects either in a model generated equilibrium or in data as the proportional departure in the pattern of trade from that which would be implied by demands for countries and regions within countries which only reflect relative country or region size (controlling for distances). This is similar to the discussion in Anderson (1979), Bergstrand (1985, 1989), Deardorf (1995), Anderson and van Wincoop (2003) in which they relate the theoretical roots of the gravity equation to CES utility functions, as also in Yi (2005).

Thus the trade effect between any regional (or country) pair *i*, *j* in their trade with region or country *k* is,

$$TE_{(i,j)k} = \frac{x_{ki}}{x_{kj}} \times \frac{y_j}{y_i}. \qquad (2)$$

where x_{ki} represents imports by k from i, x_{kj} represents imports by k from j, y_j and y_i are incomes of i and j. If there is no trade effect this ratio will be 1; if there is a trade effect it will exceed 1. We can modify (2) to yield a measure of trade effects using export data or trade flows (export and import). (2) and its modifications thus produce measures of trade effects bilaterally between all regions or countries in their trade with all other region or countries.

The reference point for measuring trade effects we take to be a model parameterization consistent with an equilibrium in which trade effects are absent. Thus, if we construct a synthetic equilibrium data set, related to observed data in the sense that incomes are unchanged for regions (and countries), but with consumption modified to yield demands which are proportional to region (and country) size, then in this equilibrium trade effects will be absent. We can generate such a parameterization using the calibration procedures set out in Dawkins, Srinivasan, and Whalley (2001), and then replace all or part of the parameterization of the model generated in this way by the parameterization generated by calibration to actual data. This procedure departs from the current literature methods discussed above of directly setting parameter values in preferences in ways which to the authors believe to remove model biases, rather than any explicit comparison to a trade neutral equilibrium.

Using data for 2001 on trade and income involving a grouping of Canadian provinces into 3 regions (Atlantic, Central, and Western Canada) and the U.S.[4] and a residual rest of the world, and taking region size weighted averages of the trade effects using (2) for the three Canadian regions yields an estimated Canada-U.S. border effect of 12.32. This figure compares with Canada-U.S. border effect reported by Anderson and van Wincoop (2003) of 10.5, and more recently by Balistreri and Hillberry (2005) of 12.8.

3. Numerical Model, Data, and Parameterization for Measuring Trade Effects

We have developed a simple numerical global general equilibrium model of 3 Canadian regions (Atlantic, Central and Western Canada) and two foreign countries (the U.S. and ROW, the rest of the world) to implement the procedures we propose for assessing the contribution of model biases to trade effects. This allows us to capture both conventional home bias and border effects. We keep the model simple and use a pure exchange type economy in which each region is endowed only with one good. The use of a pure exchange model allows us to focus only on biases in preferences and is adopted as a simplifying assumption of convenience even though it is unrealistic. Production structures and their biases can also be incorporated into this approach, but at a cost in complexity and with more difficulties in interpreting results. We incorporate 3 level nested CES preferences in all regions (and hence also in all countries). In the model prices and trade flows are endogenously determined and regional endowments are exogenously given.

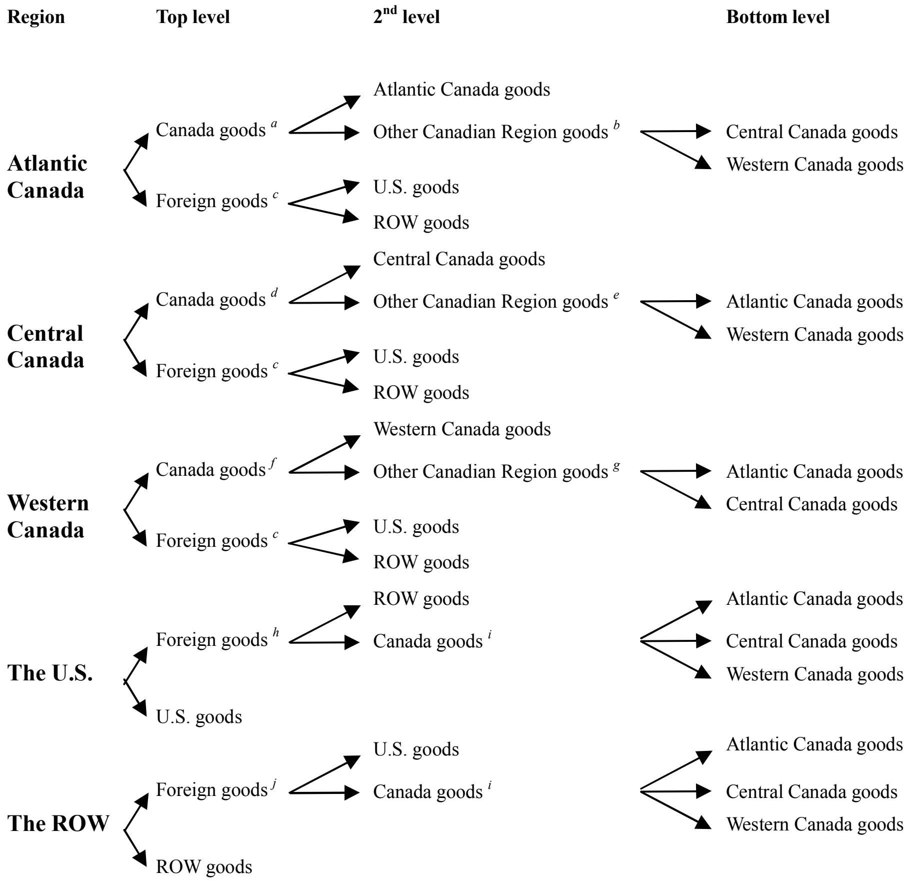
Before moving to model details, we briefly describe the nesting preferences structure used for these five regions (see Figure 3). In a conventional Armington (1969) type trade model, the preference structure directly relates to different country source goods and the nesting structure is common to all countries or regions. In our model, the nesting structure varies by region and country since different

[4] The distances between each pair of the four regions (three Canadian regions and the U.S.) are assumed to be the same.

country source goods involve a further nesting structure in which different country source goods may also be a composite of sub-region or sub-country goods. The composite good price may differ for different regions or countries.

Figure 3

Preference Trees for 5 Regions in Global General Equilibrium Model Used to Measure Trade Barriers for Canadian Regions, the U.S. and a Residual Rest of the World



Notes:

[a, d, f] *Composite of its own region good and the other Canadian region goods(sub-composite)*
[b] *Composite* of *Central and Western Canada goods*
[c] *Composite* of *the U.S. and ROW goods*
[e] *Composite* of *Atlantic and Western Canada goods*
[g] *Composite* of *Atlantic and Central Canada goods*
[h] *Composite* of *Canada (sub-composite of the three Canadian region goods) and the ROW goods*
[i] *Composite of the three Canadian region goods*
[j] *Composite* of *Canada(sub-composite of the three Canadian region goods) and the U.S. goods*

Each region is thus assumed to maximize utility by first choosing among home and foreign goods. Each region then chooses using among two foreign country goods at the 2nd level. At the second level, the three Canadian regions also choose between their own region goods and a composite of other Canadian region goods. At the bottom level, the three Canadian regions choose between the other two Canadian region goods, and the U.S and ROW choose among the three Canadian region goods.

Top level CES preferences in the various regions *s* are given by

$$D_s = \sum_i [\alpha_{si} x_{si}{}^{\rho_s}]^{1/\rho_s}, \quad i = \begin{cases} c, c^* \; if \; s = a, e, w \\ u, u^* \; if \; s = u \\ r, r^* \; if \; s = r \end{cases} \tag{3}$$

where $s \in$ (*a*, *e*, *w, u, r*)= (Atlantic Canada, Central Canada, Western Canada, the U.S., and the ROW) and relates to the regional preferences; $i \in$ (*c*, *c*, u*, *u*, r*, *r*,*)=(Canada, countries to foreign Canada, the U.S., countries foreign to the U.S, the ROW, and countries foreign to the ROW) and *i* relates to the country (or composite) good. α_{si} is the first-stage Armington share parameter, x_{si} is region *s*'s consumption of goods supplied by country *i*; and σ_s (=1/(1-ρ_s)) is the elasticity of substitution between home and foreign goods in region s.

Each of the five regions maximizes top level utility subject to the budget constraint.

$$\sum_i x_{si} p_{si} = I_s \tag{4}$$

where *i* is defined as (3), I_s is the income of region *s* (determined by the endowment, price, and transfers received, if any), p_{si} is the region *s* aggregate price index of home or foreign goods, which in turn is given by the true cost of living price index constructed using second level preferences for the region. p_{uu} and p_{rr} are the prices of US goods and ROW goods respectively as there is only one good in each region.

First order conditions yield the top level consumption of home and foreign goods in region s,

$$x_{si} = \left(\frac{\alpha_{si}}{p_{si}}\right)^{\sigma_s} \frac{I_s}{\sum_{i'=i} \alpha_{si'}{}^{\sigma_s} p_{si'}{}^{1-\sigma_s}} \tag{5}$$

where *i* is defined as in (3).

The second level preference structure relates to two foreign country goods and is also assumed to be CES. The demands at this level can be generated applying the same procedures as above, i.e.

$$x_{sjk} = \left(\frac{\alpha_{sjk}}{p_{sjk}}\right)^{\sigma_{sj}} \frac{p_{sj} x_{sj}}{\sum_{k'=k} \alpha_{sjk'}{}^{\sigma_{sj}} p_{sjk'}{}^{1-\sigma_{sj}}}, \; j,k = \begin{cases} j = c^* \text{ and } k = u,r \text{ if } s = a,e,w \\ j = u^* \text{ and } k = c,r \text{ if } s = u \\ j = r^* \text{ and } k = c,u \text{ if } s = r \end{cases} \tag{6}$$

where x_{sjk} is the demand for foreign country goods in region *s*; p_{sjk} and α_{sjk} are corresponding price and share parameters; and σ_{sj} is the elasticity of substitution between two foreign goods in region *s*.

For the three Canadian regions the second level demands for own region goods and other Canadian region goods (composite) are

$$x_{scd} = \left(\frac{\alpha_{scd}}{p_{scd}}\right)^{\sigma_{sc}} \frac{p_{sc} x_{sc}}{\sum_{d'=d} \alpha_{scd'}{}^{\sigma_{sc}} p_{scd'}{}^{1-\sigma_{sc}}}, \; s \in (a,e,w), \; d = \begin{cases} a, a^* \text{ if } s = a \\ e, e^* \text{ if } s = e \\ w, w^* \text{ if } s = w \end{cases} \tag{7}$$

where x_{scd} is region *s*'s demand for own region and the other Canadian region goods (composite),

p_{scd} is the corresponding price; α_{scd} is the share parameter; and σ_{sc} is the elasticity of substitution between own region and the other Canadian region goods.

The price indices used at the top level generated from the second level parameters and prices are

$$p_{sj} = \left[\sum_{k'=k} \alpha_{sjk'}{}^{\sigma_{sj}} p_{sjk'}{}^{1-\sigma_{sj}} \right]^{\frac{1}{1-\sigma_{sj}}} \tag{8}$$

$$p_{sc} = \left[\sum_{d'=d} \alpha_{scd'}{}^{\sigma_{sc}} p_{scd'}{}^{1-\sigma_{sc}} \right]^{\frac{1}{1-\sigma_{sc}}} \tag{9}$$

where (*j*,*k*) in equation (8) is defined as in (6), and (*s*,*d*) are as defined in (7). The bottom level utility function in region *s* is also assumed to be CES and the demands are,

$$x_{sl} = \left(\frac{\alpha_{sl}}{p_{sl}} \right)^{\sigma_{sb}} \frac{p_{smn} x_{lmn}}{\sum_{l'=l} \alpha_{sl'}{}^{\sigma_{sb}} p_{sl'}{}^{1-\sigma_{sb}}}, \quad l,m,n = \begin{cases} l = e, w \text{ and } m = c \text{ and } n = a^* & \text{if } s = a \\ l = a, w \text{ and } m = c \text{ and } n = e^* & \text{if } s = e \\ l = a, e \text{ and } m = c \text{ and } n = w^* & \text{if } s = w \\ l = a, e, w \text{ and } m = u^* \text{and } n = c & \text{if } s = u \\ l = a, e, w \text{ and } m = r^* \text{and } n = c & \text{if } s = r \end{cases} \tag{10}$$

where x_{sl} is regional demand for Canadian region goods; p_{sl} are corresponding prices, and α_{sl} share parameters; and σ_{sb} is elasticity of substitution between Canadian region goods (two or three).

Bottom level preferences also generate price indexes for the second level as

$$p_{smn} = \left[\sum_{l} \alpha_{sl}{}^{\sigma_{sb}} p_{sl}{}^{1-\sigma_{sb}} \right]^{\frac{1}{1-\sigma_{sb}}} \tag{11}$$

where (*l,m,n*) is defined as in (10).

For this pure exchange economy model the equilibrium conditions are that

$$\sum_{s} x_{ss'} = \bar{x}_{s'} \tag{12}$$

where $\bar{x}_s$ is the endowment of goods in region *s*.

The income of each region is,

$$I_s = p_s \bar{x}_s \tag{13}$$

where p_s is producer price for each region's endowment and is endogenously determined to clear markets; In a world where trade is costless and there are no transportation costs or tariffs,

$$p_{ss'} = p_{s'} \tag{14}$$

In this structure only relative prices are of any consequence and we can set the price of the U.S. good to one as the numerare, ie.

$$p_u = 1 \tag{15}$$

If transportation costs and tariff revenue are involved in the pure exchange economy model, the commodity prices are linked across regions as

$$p_{ss'} = p_{s'}(1 + t_{ss'})(1 + \tau_{ss'}) \tag{16}$$

where $t_{ss'}$ is the transportation costs per unit from *s'* to *s*, $\tau_{ss'}$ is the tariff rate in region s on imports from s'.

Assume the importing region bears the transportation costs the income of each region is,

$$I_s = \sum_{s'} p_s x_{s's} - \sum_{s'} x_{ss'} p_{s'} t_{ss'} + \sum_{s'} p_{s'} x_{ss'} (1 + t_{ss'}) \tau_{ss'} \qquad (17)$$

Equilibrium in this model differs from the simple statement in (12) in that real resource costs of transportation (denominated in terms of the commodity being shipped) needed to be factored in, and also there are government budget constraints involving tariff revenues collected and disbursed which needed to balance.

We have calibrated this model using the latest Canada data (for 2001) on interregional and international trade flows and 2001 Canada Input-Output tables from *Statistic Canada* (CANSIM Tables 386-0002 and 381-0009), supplemented by data from *Industry Canada* (Trade Data Online, available on-line at http://strategis.gc.ca), *Canada Department of Foreign Affairs and International Trade* (Third Annual Report on Canada's State of Trade 2002, available on-line at www.dfait-maeci.gc.ca/eet/state-of-trade-e.asp), U.S. *Bureau of Economic Analysis* and U.S. *Census Bureau* (FT900: U.S. International Trade in goods and Service, available on-line at www.bea.gov/bea/newsrelarchive/2006/trade1306.xls; 2001 U.S. input-output account, available on-line at www.bea.gov/bea/pn/Annual-IOMakeUse.XLS), UNCTAD (Table 7.1, Handbook of Statistics 2005, UNCTAD; available on-line at http://stats.unctad.org/Handbook/ReportFolders/ReportFolders.aspx). The 2001 observed data we use are reported in Table 1 as our benchmark data used in calibration. See Appendix A for more details.

Data on transportation costs, tariffs and non-tariffs equivalent are highly controversial in the trade literature and their size varies considerably. Anderson and van Wincoop (2004) provide a comprehensive review of this issue and transportation costs for global trade are roughly estimated by them to be around 20% of import values. Here we use this figure to represent transportation costs between the ROW and the U.S., and between the ROW and three Canadian regions. We assume 5% for internal transportation costs within the ROW. The transportation cost between each pair of the U.S. and the three Canadian regions we assume to be 2.5%. This assumption simplifies the calculation of the Canada-U.S. border effect. We use 15% as the sum of tariff and non-tariff equivalent for the U.S. and Canada trade with ROW, within the ROW 5%, and 2% between the U.S. and three Canadian regions[5].

In executing our calibration, we introduce an additional endowment of goods besides the physical endowments in the simple no transportation cost no tariff pure exchange model into the model with these elements (see Appendix B for more details). This is because if transportation costs are required for the trade flows between *s*' and s, each region has to spend a certain amount of its endowment to ship goods from other regions (including itself if the region is not treated as spot anymore). The data set for both the U.S. and Canada as reported in Appendix A does not provide information on transportation costs. We assume importing regions bear transportation costs and the resulting price markup of imported goods. If tariffs are also involved in trade flows, the importing region can also collect duties on imported goods. When both transportation costs and tariffs are involved in shipping goods between regions, there is a discrepancy between region incomes and expenditures on goods. To create a modified benchmark data set for calibration, we introduce a additional endowment of region s besides its physical endowment. This additional endowment is owned by the region and used to cover shipping costs from exporting regions and hence the price markup of imported goods. For this benchmarking, the ratios of additional to physical endowments for the five regions are as follows. For Atlantic Canada it is 18.3%, Central

[5] In Anderson and van Wincoop (2004) the simple tariff rates for the U.S. and Canada are 2.9% and 4.5%; the broad NTB ratios for the U.S. and Canada are 27.2% and 30.7%; narrow NTB ratios for the U.S. and Canada are 0.015 and 0.015. We use an 15%, which is roughly the sum of tariffs and the average of broad and narrow NTB ratios, as the sum of tariff and non-tariff equivalent for the U.S. and Canada trade with ROW.

Canada 2.6%, Western Canada 4.9%, the U.S. 10.4%, and the ROW 9.4%. These additional endowments remain fixed as we conduct counterfactual equilibrium analyses removing model biases from the model. The values of these additional endowments are reported in the last row of Table 1.

Table 1: Observed Data of 2001 Canadian Regional and International Trade Flows and Benchmarking (10 billion Dollars).

From / To	Atlantic Canada	Central Canada	Western Canada	The U.S.	The ROW
Atlantic Canada	9.133	1.636	0.186	0.416	1.884
Central Canada	0.898	104.614	3.549	21.357	6.786
Western Canada	0.122	5.054	47.032	3.279	5.331
The U.S.	1.646	27.879	8.839	2693.958	197.773
The ROW	0.519	3.500	3.036	130.547	6712.546
Physical Endowment	12.318	142.683	62.642	2849.557	6924.320
Additional Endowment for Transportation Costs	2.259	3.756	3.083	296.263	652.123

Notes: All trade flows are valued at producer prices and F.O.B.
Notes: Atlantic Canada constitutes *Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick*. Atlantic Canada constitutes Quebec, Ontario and Manitoba. West Canada constitutes the rest of Canada (*Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut*).
Source: *Statistics Canada*, *Industry Canada*, Canada *Department of Foreign Affairs and International Trade, U.S. Bureau of Economic Analysis, U.S. Census Bureau, and UNCTAD. See Appendix A and B for details.*

Table 2: Neutrality Data with Absence of Trade Effects (10 billion Dollars)

From / To	Atlantic Canada	Central Canada	Western Canada	The U.S.	The ROW
Atlantic Canada	0.019	0.195	0.088	4.188	10.087
Central Canada	0.195	1.959	0.879	42.074	101.332
Western Canada	0.088	0.879	0.395	18.884	45.480
The U.S.	4.188	42.074	18.884	903.843	2176.831
The ROW	10.087	101.332	45.480	2176.831	5242.713

Note: Constructed based on Table 1. See Appendix C for details.

Using the benchmark data, we also construct a trade neutral data with absence of trade effects (Table 2, see Appendix C for more details). In this, each region consumes goods from all regions proportional to their income share in the combined global economy.

Since elasticities of substitution play an important role in model results, when addressing the relationship between home bias and the border effect using the calibrated version of this model, we appeal to literature sources for the values we use. The estimated magnitudes of key elasticities differ across various studies (Bergstrand, 1985; Shiells, Stern and Deardorff ,1986; Feenstra, 1994; Hummels, 1999; Bloningen and Wilson, 1999; Baier and Bergstrand, 2001; Head and Ries, 2001; and Saito, 2004; Yi, 2003)[6]. We use an elasticity of substitution of 2.0 for the top level sub-utility function in each region and 2.5 for the second level sub-utility functions of two foreign country goods, 3.0 in three Canadian regions for the own region goods and other Canadian region goods, and 3.0 for the bottom level in each region.

The parameterizations consistent with benchmark data and synthetic trade neutral data are reported in Table 3. The substantial difference in the top level share parameters in preferences between the trade neutral and observed cases suggest that in all 5 regions there is a strong country bias in favor of own country goods (home bias). Home bias is thus present in all three Canadian regions, in the U.S., and in the ROW. The differences in the second level share parameters between neutrality case and observed case suggest that both Atlantic and Western Canada favors the ROW goods rather than the U.S. goods, while Central Canada favors the U.S. goods instead of the ROW goods. The U.S. has slight bias toward Canada goods rather than the ROW goods, while the ROW slight bias toward the U.S. instead of Canada goods. All three Canadian regions have a strong bias toward own region goods. The bottom level regional share parameters suggest that Atlantic (Western) Canada favor Central Canada goods rather than Western (Atlantic) goods. Central Canada has a slightly bias toward Atlantic goods instead of Western Canada goods. Both the U.S. and the ROW reveal no significant bias among three Canadian region goods.

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[6] Anderson and van Wincoop (2004) as well as Saito (2004) provide a comprehensive review of the magnitude of elasticity parameter in different studies.

Table 3: Calibrated Share Parameters in Nested CES Utility Functions

	Top Level		2nd Level for Foreign Country Goods			2nd Level for Canadian Region Goods		Bottom Level for Canadian Goods		
Region	Home	Foreign	Canada	U.S.	ROW	Own Region	Other Canadian Region	Atlantic Canada	Central Canada	Western Canada
					Trade Neutral Data					
Atlantic Canada	0.146	0.854	--	0.413	0.587	0.208	0.792	--	0.567	0.433
Central Canada	0.146	0.854	--	0.413	0.587	0.449	0.551	0.377	--	0.623
Western Canada	0.146	0.854	--	0.413	0.587	0.343	0.657	0.317	0.683	--
The U.S.	0.321	0.679	0.307	--	0.693	--	--	0.208	0.449	0.343
The ROW	0.505	0.495	0.387	0.613	--	--	--	0.208	0.449	0.343
					Observed Data					
Atlantic Canada	0.663	0.337	--	0.293	0.707	0.544	0.456	--	0.674	0.326
Central Canada	0.632	0.368	--	0.545	0.455	0.654	0.346	0.387	--	0.612
Western Canada	0.670	0.330	--	0.384	0.616	0.620	0.380	0.224	0.776	--
The U.S.	0.634	0.366	0.408	--	0.592	--	--	0.188	0.483	0.329
The ROW	0.796	0.204	0.364	0.636	--	--	--	0.213	0.403	0.384

Note: -- These entries do not exist in the model for this region.

4. Assessing the Contribution of Model Biases to Trade Effects

We have used this calibrated model to assess the contribution of home and regional bias to border effects both in the simple pure exchange economy case and in the presence of tariffs and transportation costs. To do this, we use counterfactual analyses in which we jointly or separately change share parameters in preferences at different levels in different regions in each model form. Table 4 reports model results for the impacts on the Canada-U.S. border effect in the presence of biases in the calibrated trade model. In these experiments we have replaced the share parameters generated by calibration in the trade neutral model case with the share parameters generated by calibration to the observed 2001 data. These experiments are performed jointly or separately in the various regions and at different levels.

Overlying the parameterization generated by calibration to the observed data suggests bias in all regions at all levels and yields a border effect of 11.30 which is close to size to the border effect of 12.32 generated by actual data in 2001. This suggests that the bias structure in preferences in the model can generate a similar size of border effect compared to data even without transportation costs and trade barriers. Biases in Canada regions only generate a border effect of 5.87 and in the U.S. of 2.18, while the presence of biases in the ROW reduces the Canada-U.S. border effect.

Country biases (top level bias) in all regions generate a border effect of 130.00. The presence of Canada country bias generates a border effect of 43.50 which is over 3.5 times the size of the data generated border effect for 2001, and as such shows how Canadian home bias can be separated out in terms of its separate influences on the Canada-U.S. border effect. The presence of country bias in the U.S. generates a border effect of 4.21 and in the ROW 0.60. This suggests that the U.S. country bias intensifies the Canada-U.S. border effect while the ROW bias reduces the Canada-U.S. border effect. The presence of country biases in both the U.S. and the ROW together generate a border effect of 4.41, which is around one third of the border effect in 2001.

These results also suggest that the presence of the biases for different foreign country goods in all regions collectively reduces the border effect, among which biases in Canadian regions and the ROW have almost no impacts while biases in the U.S. reduces the border effect. The presence of biases in preferences for country level goods generates a border effect of 69.59, biases in Canadian regions only 36.29, the U.S. 2.23, and the ROW 0.63.

Regional biases toward own region goods rather than the other Canadian region goods in the three Canadian regions reduce the Canada-U.S. border effect. This suggests that regional biases also play a central role in the determination of border effects, since the border effect is transformed into a reverse border effect. The presence of biases in preferences over two other Canadian region goods has only a small effect on the border effect, as does biases in preferences in both the U.S. and ROW.

We have also examined the impacts of removing biases from the parameterization generated by calibration to the observed data on the Canada-U.S. border effect and the reverse of the experiments reported in Table 4. Results for these cases are broadly consistent with those reported in Table 4[7].

We have also conducted experiments similar to those reported in Table 4, but in which transportation costs are present in the model, and vary across each pair of the three Canadian regions and the U.S. Transportation costs between the U.S. and the Canadian is assumed to be 5% as in Yi (2005). Internal transportation costs within the U.S. are assumed to be 2.5% and within the three Canadian regions 1%, and 1% for shipping between the three Canadian regions. The impacts of the biases in these cases on the Canada-U.S. border effect are reported in Table 5. These results are similar to those reported in Table 4 and suggest that the impacts of biases on the estimated Canada-U.S. border effects are not sensitive to the treatment of transportation costs involving shipments between Canadian regions and the U.S.

Table 4: Impacts on the Canada-U.S. Border Effect with the Presence of Model Biases

	All Levels	Top level	2nd Level for Foreign Country Goods	The Top and 2nd Level for Foreign Country Goods	2nd Level for Canada Goods	Bottom Level for Canada Goods	2nd and Bottom Level for Canada Goods
Neutrality Data	1.00						
Observed Data	12.32						
All 5 regions	11.30	130.00	0.46	69.59	--	1.13	0.19
Canada Regions only	5.87	43.50	0.84	36.29	0.16	1.16	0.19
The U.S. and ROW only	2.30	4.41	0.53	2.38	--	0.95	--
The U.S. only	2.18	4.21	0.51	2.23	--	0.98	--
The ROW only	0.62	0.60	1.09	0.63	--	0.99	--

Notes:
-- These entries do not exist in the model for this region.
The Canada-U.S. border effect is the region size weighted average border effect of the three Canadian regions.

7 Results for these experiments are available upon request.

Table 5: Impacts on the Canada-U.S. Border Effect with the Presence of Biases with Different Transportation Costs

	All Levels	Top level	2nd Level for Foreign Country Goods	The Top and 2nd Level for Foreign Country Goods	2nd Level for Canada Goods	Bottom Level for Canada Goods	2nd and Bottom Level for Canada Goods
Neutrality Data	1.00						
Observed Data	12.21						
All 5 regions	10.55	127.33	0.43	64.75	--	1.13	0.19
Canada Regions only	5.74	43.19	0.82	35.35	0.16	1.16	0.19
The U.S. and ROW only	2.16	4.33	0.50	2.23	--	0.95	--
The U.S. only	2.05	4.15	0.48	2.09	--	0.98	--
The ROW only	0.62	0.60	1.08	0.63	--	0.99	--

Notes:
-- These entries do not exist in the model for this region.
The Canada-U.S. border effect is the region size weighted average border effect of the three Canadian regions.

As noted in the literature, the Canada-U.S. border effects vary across Canadian regions. We also find that the border effect varies across trade directions as well. Table 6 reports more detailed calculations of the impacts of biases in preferences on the Canada-U.S. border effect depending on the trade direction. These results show that the effects of bias are similar on the Canada-U.S. border effects in different Canadian regions as well by trade directions in some cases, however, different in other cases.

Table 6: The Presence of Biases on the Canada-U.S. Border Effect by Canadian Regions and Trade Direction

	Export				Import				Bilateral Trade			
	Canada	Atlantic Canada	Central Canada	Western Canada	Canada	Atlantic Canada	Central Canada	Western Canada	Canada	Atlantic Canada	Central Canada	Western Canada
Neutrality	1.00	1.00	1.00 (1.00)	1.00	1.00	1.00	1.00 (1.00)	1.00	1.00	1.00	1.00 (1.00)	1.00
Observed	9.71	11.69	12.65 (8.67)	8.60	21.11	84.27	9.06 (7.95)	33.03	12.32	26.33	11.09 (8.35)	15.21
Biases at all levels												
All regions	9.74	12.46	11.57 (9.39)	9.17	16.92	66.94	11.10 (6.38)	28.46	11.30	21.51	11.34 (7.90)	15.48
Canada	9.54	8.07	13.09 (10.32)	7.07	5.51	22.94	2.92 (2.00)	9.27	5.87	12.79	5.24 (3.89)	8.26
The U.S.	1.36	1.98	1.17 (1.17)	1.66	5.30	4.78	5.85 (5.52)	4.78	2.18	2.69	2.10 (2.03)	2.39
The ROW	0.63	0.63	0.63 (0.63)	0.63	0.61	0.71	0.61 (0.54)	0.71	0.62	0.67	0.62 (0.59)	0.67
Biases at Top Level												
All regions	125.21	119.13	127.27 (128.82)	119.13	136.98	159.25	120.46 (120.46)	168.85	130.00	136.95	123.88 (124.66)	140.65
Canada	54.34	50.17	55.72 (56.83)	50.17	36.42	42.34	32.03 (32.03)	44.90	43.50	45.72	41.26 (41.69)	47.22
The U.S.	3.39	3.39	3.39 (3.39)	3.39	5.56	5.56	5.56 (5.56)	5.56	4.21	4.21	4.21 (4.21)	4.21
The ROW	0.63	0.63	0.63 (0.63)	0.63	0.57	0.57	0.57 (0.57)	0.57	0.60	0.60	0.60 (0.60)	0.60
Biases in preferences of two foreign country goods at 2nd level												
All regions	0.40	0.42	0.34 (0.39)	0.42	0.66	2.04	0.39 (0.39)	0.97	0.46	0.66	0.37 (0.39)	0.58
Canada	0.98	1.03	0.86 (0.97)	1.03	0.85	2.60	0.50 (0.50)	1.24	0.84	1.42	0.62 (0.66)	1.12
The U.S.	0.41	0.41	0.41 (0.41)	0.41	0.67	0.67	0.67 (0.67)	0.67	0.51	0.51	0.51 (0.51)	0.51
The ROW	0.98	0.98	0.98 (0.98)	0.98	1.23	1.23	1.23 (1.23)	1.23	1.09	1.09	1.09 (1.09)	1.09
Biases in preferences of two foreign country goods at top and 2nd level												
All regions	59.94	56.72	59.89 (62.12)	56.72	110.77	354.71	54.54 (54.54)	181.96	69.59	99.77	57.16 (58.25)	88.59
Canada	54.02	50.85	52.87 (56.41)	50.85	33.29	109.02	15.94 (15.94)	55.15	36.29	69.85	24.75 (25.60)	53.02
The U.S.	1.42	1.42	1.42 (1.42)	1.42	5.20	5.20	5.20 (5.20)	5.20	2.23	2.23	2.23 (2.23)	2.23
The ROW	0.63	0.63	0.63 (0.63)	0.63	0.64	0.64	0.64 (0.64)	0.64	0.63	0.63	0.63 (0.63)	0.63
Biases in preferences of own region or other two Canadian region goods (composite) at 2nd level												
Canada	0.15	0.17	0.16 (0.14)	0.17	0.16	0.16	0.17 (0.17)	0.14	0.16	0.17	0.17 (0.16)	0.16
Biases at bottom level												
All regions	1.12	1.51	1.20 (1.06)	1.11	1.07	1.72	1.10 0.70 ()	1.52	1.13	1.63	1.16 (0.92)	1.36
Canada	1.21	1.09	1.49 (1.30)	0.96	1.11	1.49	1.09 (0.96)	1.30	1.16	1.29	1.29 (1.13)	1.13
The U.S.	0.96	1.39	0.83 (0.83)	1.17	1.02	0.93	1.12 (1.06)	0.93	0.98	1.13	0.97 (0.94)	1.04
The ROW	0.99	0.99	0.99 (0.99)	0.99	0.95	1.29	0.90 (0.70)	1.29	0.99	1.15	0.95 (0.86)	1.17

Note: The Canada-U.S. border effect associated with Atlantic and Western Canada refers to Central Canada, and Central Canada's border effect refers to Atlantic (Western), and Central Canada.

5. Concluding Remarks

Despite substantial literature over the last 10 years on both home bias and the border effect, these two terms remain somewhat mysterious (especially home bias) and are used in the literature in a number of different ways. Here we provide both clarification of terminology and numerical simulation procedures for separating out the separate influences of home and other model biases on a measured border effect.

Using a calibrated model of 3 region Canadian and country U.S. and ROW trade model to 2001 data we report decomposition results using general equilibrium computations which the separate influences of various model biases on measured border effects are assessed in terms of impacts on trade flows relative to synthetic trade neutral equilibrium data set constructed using observed data. The presence of biases in preferences in all regions at all levels generates a model calculated border effect almost equal to the border effect as measured by data for 2001. The biases in Canada's regions generate a border effect of 5.68 and the U.S. 2.27, while the biases in the ROW reduce the Canada-U.S. border effect. The home bias in Canada regions generates a border effect of 41.39, the U.S. 4.62 and the ROW 0.59. Regional biases in preferences of Canadian regions strongly reduce the Canada-U.S. border effect. Our results also suggest that biases in preferences across different regions and trade directions can have different impacts on the Canada-U.S. border effect.

References

Anderson, J.E., 1979. A Theoretical Foundation for the Gravity Equation, *American Economic Review*, 69(1), pp. 106-116.

Anderson, J.E., and E. van Wincoop, 2003. Gravity with Gravitas: A Solution to the Border Puzzle, *American Economic Review*, 93(1), pp. 170-192.

Anderson, J.E., and E. van Wincoop, 2004. Trade Costs, *Journal of Economic Literature,* 42(3), pp. 691-751.

Anderson, M.A. and S. L. S. Smith, 1999. Do National Borders Really Matter? Canada-US Regional Trade Reconsidered, *Review of International Economics*, 7(2), pp. 219-227.

Armington, P.S., 1965. A Theory of Demand for Products Distinguished by Place of Production, International Monetary Fund Staff Papers, 16 (1), pp. 159-178

Baier, S.L., and J.H. Bergstrand, 2001. The Growth of World Trade: Tariffs, Transport Costs and Income Similarities, *Journal of International Economics*, 53(1), pp. 1–27.

Balistreri W.J., and R.H. Hillberry, 2005. Structural Estimation and the Border Puzzle, Mimeo, the University of Melbourne.

Bergstrand, J. H., 1985. The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence, *Review of Economics and Statistics*, 67(3), pp. 474-481.

Bergstrand, J.H., 1989. The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade, *Review of Economics and Statistics*, 71(1), pp. 143–53.

Blonigen, B. A., and W. W. Wilson, 1999. Explaining Armington: What Determines Substitutability between Home and Foreign Goods, *Canadian Journal of Economics*, 32 (1), pp. 1–22.

Brulhart, M., and F. Trionfetti, 2001. A Test of Trade Theories When Expenditure Is Home Biased, mimeo, University of Lausanne.

Dawkins, C., T.N. Srinivasan, and J. Whalley, 2001. Calibration, in (J. J. Heckman and E. Leamer, eds), *Handbook of Econometrics*, Vol.5 (North-Holland, Amsterdam).

Deardorff, A.V., 1995. Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?, NBER Working Paper No. 5377.

Engel, C. and J.H. Rogers,1996. How Wide Is the Border? *American Economic Review*, 86(5), pp. 1112-1125.

Evans, C. L., 2003. The Economic Significance of National Border Effects, *American Economic Review*, 93(4), pp. 1292-1312.

Fairfield, J.E., 2001. Canada-U.S. Border Effects: An Examination, Ph.D. Thesis, Department of Economics, the University of Western Ontario

Feenstra, R.C., 1994. New Product Varieties and the Measurement of International Prices, *American Economics Review*, Vol. 84, No. 1, pp. 157–77.

Head K. and T. Mayer, 2002. Illusory Border Effects: Distance Mis-measurement Inflates Estimation of Home Bias in Trade, Mimeo, University of British Columbia

Head, K. and J. Ries, 2001. Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of US-Canada Trade, *American Economic Review*, 91(4), pp. 858-876

Helliwell, J.F., 1996. Do National Boundaries Matter for Quebec's Trade?, *Canadian Journal of Economics*, 29(3), pp. 507-522.

Helliwell, J.F., 1998. How Much Do National Borders Matter? Washington, DC: Brookings Institution Press, 1998.

Hillberry, R.H. and D. Hummels, 2002. Explaining Home Bias in Consumption: the Role of Intermediate Input Trade, NBER Working Paper No.9020

Hillberry, R.H. and D. Hummels, 2003. Intra-National Home Bias: Some Explanations, *Review of Economics and Statistics*, 85(4), pp. 1089-92.

Hillberry, R.H., 2002. Aggregation Bias, Compositional Change, and the Border Effect, *Canadian Journal of Economics*, 35(3), pp. 517-530.

Hummels, D., 1999. Towards a Geography of Trade Costs, University of Chicago.

McCallum, J., 1995. National Border Matters: Canada-U.S. Regional Trade Patterns, *American Economic Review*, 85(3): pp615-623

Obstfeld, M., and K. Rogoff, 2000. The Six Major Puzzles in International Macroeconomics: Is There a Common Cause? NBER working paper, No. 7777

Saito, M., 2004. Armington Elasticities in Intermediate Inputs Trade: A Problem in Using Multilateral Trade Data, IMF Working Paper, WP/04/22

Shiells, C. R., R. M. Stern, and A. V. Deardorff, 1986. Estimates of the Elasticities of Substitution between Imports and Home Goods for the United States, *Weltwirtschaftliches Archiv*, 122(3), pp. 497–519

Trelfer, D., 1995. The Case of Missing Trade and other Mysteries, *American Economic Review*, 85(3): pp1029-1046

Wall, H.J., 2000. Gravity Model Specification and the Effects of the Canada-U.S. Border, Working Paper 2000-024A, Federal Reserve Bank of St. Louis

Wei, S.J., 1996. Intra-national versus International Trade: How Stubborn Are Nations in Global Integration, NBER working paper No. 5531

Whalley, J., 1985. *Trade Liberalization among Major World Trade Areas*, Cambridge, Mass: MIT Press.

Wolf, H.C. 2000. Intra-national Home Bias in Trade, *Review of Economics and Statistics* 82(4), pp. 555-563.

Yi, K., 2003. Can Vertical Specialization Explain the Growth of World Trade? *Journal of Political Economy*, 111 (1), pp. 52-102

Yi, K., 2005. Vertical Specialization and the Border Effect Puzzle, Working Paper No.05-24, Research Department, Federal Reserve Bank of Philadelphia

Appendix:
Data on Canadian Regional and International Trade Flows

A: Sources for Observed trade flows in 2001 in Table 1.

Canadian provinces are grouped into three Canadian regions. Atlantic Canada constitutes *Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick*. Atlantic Canada constitutes Quebec, Ontario and Manitoba. West Canada constitutes the rest of Canada (*Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut*).

All trade flows data refers to 2001 and valued at Canadian dollars. Exchange rate of the Canadian dollar in 2001 is 0.6458 of the U.S. dollar. This exchange rate, obtained from the *Bank of Canada*, is used by both *Statistics Canada* and *Industry Canada* in 2001 trade data.

Inter-provincial trade (goods and services) flows between the three Canadian regions are from *Statistic Canada* (CANSIM Table 386-0002), in which the trade flows are measured at 2001 producer price.

Data on the three Canadian region goods exports to and imports from the U.S. are from *Industry Canada* (Trade Data Online, available on-line at http://strategis.gc.ca). In this data set, both international exports and imports are valued at F.O.B. (free on board) prices. This data set only offers data on international trade flows in goods. Third Annual Report on Canada's State of Trade 2002 (*The Department of Foreign Affairs and International Trade*; Available on-line at www.dfait-maeci.gc.ca/eet/state-of-trade-e.asp) offers an estimate of 8.3% for services export share in Canada's total exports to the U.S. and 12.9% for services import share in Canada's total imports from the U.S. in 2001. Using these two shares we obtain international trade flows in goods and services between U.S. and the three Canadian regions.

Statistic Canada (CANSIM Table 386-0002) also offers data on Canadian region total international exports and imports of goods and services at producer prices. We can thus use this data set and international trade flows between U.S. and three Canadian regions to obtain international trade flows between the ROW and the three Canadian regions.

U.S. total international exports and imports in goods and services are obtained from U.S. *Bureau* *of Economic Analysis* and U.S. *Census Bureau* (FT900: U.S. International Trade in goods and Service; Available on-line at www.bea.gov/bea/newsrelarchive/2006/trade1306.xls) and converted to Canadian dollars using the exchange rate as above. Both international exports and imports are valued F.O.B. in this data set. International trade flows between the U.S. and the ROW are obtained by subtracting U.S. international trade flows with Canada from total U.S. international trade flows.

Domestic use of U.S. goods and services are obtained by subtracting U.S. international exports from U.S. total industry outputs. U.S. total industry outputs are obtained from U.S. *Bureau of Economic Analysis* (2001 U.S. input-output account; Available on-line at www.bea.gov/bea/pn/Annual-IOMakeUse.XLS) and converted to Canadian dollars using the exchange rate as above.

Intra-ROW use of ROW goods and services are also obtained by subtracting ROW international exports from ROW total industry outputs. ROW total international exports are the sum of U.S. and Canada imports from ROW obtained as above (at F.O.B. prices). ROW total industry output is obtained by using ROW GDP divided by its value-added ratio. ROW GDP is obtained from UNCTAD (Table 7.1, Handbook of Statistics 2005, UNCTAD; available on-line at http://stats.unctad.org/Handbook/ReportFolders/ReportFolders.aspx). ROW GDP share in world GDP was 65.62% in 2001. The ROW economy comprises of two parts, the developed economies and developing economies. The developed economies in the ROW produced 43.03% of world GDP and the developing economies produced 22.60% of world GDP in 2001. We use China's value-added share (35.86%, from China Statistical Year Book 2005, *National Bureau of Statistics China* (2005)) in 2001 as of the developing economies, and the simple average (51.73%) of the U.S. and Canada value-added share (55.03% for the U.S. obtained from U.S. *Bureau of Economic Analysis* (2001 U.S. input-output account; Available on-line at www.bea.gov/bea/pn/Annual-IOMakeUse.XLS); and 48.42% for Canada obtained from *Statistic Canada* (Canada Input-Output tables, CANSIM Table 381-0009)). Using the GDP weighed sum of developing economy value-added share and developed economy value-added share yields an estimate of value-added share of 46.26% for the ROW and thus ROW total industry outputs can be obtained and then converted into Canadian dollars.

The trade flows between five regions at valued at producer prices as above. Data on transportation costs and tariffs and non-tariffs equivalent are highly controversial in the trade literature and the magnitudes vary drastically. Anderson and Van Wincoop (2004) provide a comprehensive review over this issue and transportation costs are roughly estimated around 20% of national income. Here we use this figure to represent transportation costs between the ROW and the U.S., between the ROW and three Canadian regions, 5% for internal transportation costs within the ROW. The transportation cost between each pair of the U.S. and the three Canadian regions is assumed to be 2.5%. This assumption could simplify the calculation of the Canada-U.S. border effect. We use 15% as the sum of tariff and non-tariff equivalent for the U.S. and Canada trade with ROW, within the ROW 5%, and 2% between the U.S. and three Canadian regions.

B: The Benchmarking of Observed Trade Flows in 2001 in the Presence of Tariffs and Transportation Costs

If transportation costs are involved in the trade flows from *s*' to s, each region has to spend a certain amount of its endowment on shipping goods from other regions (including itself if the region is not treated as concentrated single point). The data set for both the U.S. and Canada detailed in Appendix A does not provide information on transportation costs. We assume importing region bears the transportation costs and also suffers the price markup of imported goods, and tariffs are also involved with trade flows and the importing region collects duties on imported goods. When both transportation costs and tariffs are involved in shipping goods between regions, there is a discrepancy between regional income and expenditure on goods unless adjustment is made to the endowments of each region. The expenditure on goods in region s is,

$$E_s = \sum_{s'} p_{s'} x_{ss'} (1 + t_{ss'})(1 + \tau_{ss'}) \qquad \text{(A1)}$$

where $p_{s'}$ is the price of endowment in region s'; $t_{ss'}$ is the transportation costs per unit value from *s*' to *s*, $\tau_{ss'}$ is the tariff rate levied by region s on goods from region s'.

The income of region s in the absence of any adjustment for resources use in transportation costs is,

$$I_s = \sum_{s'} p_{s's} x_{s's} - \sum_{s'} x_{ss'} p_{s'} t_{ss'} + \sum_{s'} p_{s'} x_{ss'} (1 + t_{ss'}) \tau_{ss'} \qquad \text{(A2)}$$

The difference D_s between E_s and I_s is,

$$D_s = \sum_{s'} p_{s'} x_{ss'} (1 + 2t_{ss'}) - \sum_{s'} p_s x_{s's} \qquad \text{(A3)}$$

To create a benchmark data set for the general equilibrium model in the presence of transportation costs, we introduce D_s as an additional endowment of region s besides its physical endowment of $\sum_{s'} x_{s's}$ in the pure exchange case. This additional endowment is assumed owned by the region and used to cover shipping costs from exporting regions and price markups for imported goods. For benchmarking, the ratios of additional endowments to physical endowments for the five regions are: Atlantic Canada 18.3%, Central Canada 2.6%, Western Canada 4.9%, the U.S. 10.4%, and the ROW 9.4%, respectively.

C: Neutrality Data

In a trade costless world, the neutrality data set with absence of trade effects is created as follows. Each region consumes goods from all regions proportional to its income share in world economy, i.e.,

$$x_{ss'} = \frac{\sum_{\omega} x_{\omega s}}{\sum_{\theta} \sum_{\omega} x_{\omega\theta}} \cdot \sum_{\omega} x_{\omega s'} \qquad \text{(A4)}$$

where $x_{ss'}$ is trade flows from *s*' to s; ω, $\theta \in$ (*a*, *e*, *w, u, r*)= (Atlantic Canada, Central Canada, Western Canada, the U.S., and the ROW). The nominator of the first part on the right hand side of (A4) is the endowment of region s and the denominator is world endowment. The second part on the right hand side of (A4) is the endowment of region s'.

To create the neutrality trade flows absent of trade effects with benchmarking data obtained in Appendix B, we sum up the additional endowment and the value of physical endowment to yield a total endowment for each region. Applying (A4) yields the neutrality trade flows as in Table 2.