

# Internal Trade and Aggregate Productivity: Evidence from Canada

Trevor Tombe\* and Jennifer Winter†

February 2013

*Preliminary and Incomplete - Comments Welcome*

## Abstract

The positive link between international trade and productivity is well established. However, research on magnitude and consequences of internal trade barriers, which inhibit the efficient geographic distribution of production within a country, is limited. Unique Canadian data provides an ideal opportunity to measure the magnitude - and impact on productivity - of barriers to internal trade. Using a flexible, micro-founded approach, we measure internal trade barriers between Canadian provinces. We find between-province trade costs average 30%, rising to nearly 50% in poor regions, net of distance effects. We then adapt a new-trade model to estimate the productivity impact of these barriers. Eliminating inter-provincial trade barriers increases productivity by over 15% in the median province and by over 8% for Canada as a whole, accounting for nearly half the productivity gap with the United States. For comparison, we find these benefits are larger than lowering international trade barriers by 20%. Internal trade barriers also account for over 40% of the regional income inequality across provinces. Using our flexible measure of trade costs between provinces over time, we can estimate the change in trade costs from changes in internal trade policies, such as the Agreement on Internal Trade. Preliminary results indicate average bilateral trade costs fell by slightly over 10% following implementation of the AIT.

*JEL Classification:* F4, F1, R1

*Keywords:* Internal trade; Productivity; Regional economic development

---

\* Assistant Professor, Department of Economics, University of Calgary. Email: [ttombe@ucalgary.ca](mailto:ttombe@ucalgary.ca).

† Research Associate, The School of Public Policy, University of Calgary. Email: [jwinter@ucalgary.ca](mailto:jwinter@ucalgary.ca).

# 1 Introduction

Research consistently finds openness to international trade contributes to aggregate productivity.<sup>1</sup> Openness to trade between regions of the same country should have similar benefits, as internal trade barriers protect inefficient production in low-productivity regions. In Canada, for instance, manufacturing in Prince Edward Island produces *half as much per worker* as in Ontario while aggregate labour productivity in PEI is only 75% of Ontario's. Trade barriers may create an incentive for regions to produce goods of relatively lower productivity.<sup>2</sup> Removing these geographic misallocations would increase aggregate productivity and allow workers and firms in low-productivity regions to focus on activities they are relatively better at.<sup>3</sup> Unfortunately, methodological and data limitations have prevented past research from estimating broad and systematic measures of internal barriers to trade or their impact on productivity. Our contribution is to adapt recent new-trade frameworks from the international trade literature to fit unique Canadian data on internal output and trade. We estimate: (1) the size of overall internal trade costs; (2) the effectiveness of government policies aimed at reducing these costs; and (3) the effect of internal trade costs on national and regional productivity.

We estimate intra-national trade barriers using two alternative - and complementary - approaches. First, we adopt a flexible, micro-founded approach following Novy (2011). First developed to estimate nineteenth-century international trade costs (see Jacks et al., 2008, 2010, 2011), this method relates trade costs to trade flow volumes between an importer and exporter pair, relative to each partner's domestic absorption. The less a given region trades with another, relative to what it consumes from its own production, the higher the trade cost we infer between these regions. These data are not readily available in other countries but do exist for Canada. This method is flexible in that it holds for a wide variety of trade models, including Eaton and Kortum (2002), Anderson and van Wincoop (2003), Melitz (2003), and Melitz and Ottaviano (2008). We postpone a detailed description of this method to Section 3.2. Overall, we find large internal trade costs. Expressed in terms of an effective tax when crossing a provincial boundary, these costs range from 100% between Atlantic and Western provinces to approximately 40% between Ontario and Quebec. This method, while able to distinguish trade costs from within-province distribution and marketing costs, does not net out the effect of distance. We adjust these estimates and find average bilateral costs of 30%.

Another shortcoming of the Novy (2011) approach is that it assumes pair-specific costs, where both partners face identical costs. Our second approach, which builds upon the trade models of Eaton and Kortum (2001, 2002) and Alvarez and Lucas (2007), can provide importer-specific import costs. We provide details of the model in Section 4. Overall, results from the model point to similar patterns of internal trade costs in Canada. We find buyers in Atlantic provinces face import costs nearly 40% higher than Ontario buyers, while buyers in Alberta face only marginally higher

---

<sup>1</sup>See, for example, Frankel and Romer (1999); Bernard and Jensen (2001); Trefler (2004); Pavcnik (2002); Eaton and Kortum (2001); Bernard et al. (2006); Amiti and Konings (2007); Tombe (2010); Waugh (2010) and Topalova and Khandelwal (2011).

<sup>2</sup>This is certainly the case for PEI food processors; locating there to avoid restrictions on the inter-provincial movement of agricultural goods.

<sup>3</sup>It is well known in other contexts that misallocation can lower aggregate productivity, for instance across firms and sectors. See, e.g., Hsieh and Klenow (2009); Brandt et al. (2010) and Adamopoulos (2011).

import costs. This approach can also relate trade costs and productivity, following recent work by Waugh (2010) and Tombe (2010), allowing us to estimate the counterfactual effect of a reduction in trade costs on productivity. If trade costs fall, then imported goods and services become substitutes for lower-productivity local producers. We find eliminating internal barriers increases Canada's aggregate labour productivity by over 8%, and by significantly more in poorer provinces. These gains account for half the productivity gap between Canada and the United States. Beyond increasing overall productivity, liberalized internal trade can reduce inequality across provinces by nearly half. We perform a variety of additional experiments; in particular we find the gains from internal liberalization roughly equivalent to lowering international trade barriers by 20%.

Given the large gains from liberalizing internal trade, a natural question is what these costs are and whether government policy reforms can effectively lower internal trade costs. Our trade cost estimates capture a variety of factors inhibiting trade.<sup>4</sup> Province-specific occupational licenses prevent an accountant or broker in one province from offering services in another. Home-biased government procurement policies favour less efficient local suppliers. Local marketing boards for various agricultural goods prevent shipping output from one province to another, with spillover consequences for the food processing sector. Nonuniform trucking regulations, with varying axle weight and dimension regulations, will impact all trade in goods by making truck shipments more expensive. Significant political capital is expended by political leaders in Canada attempting to lower these barriers. The issue has been identified as a key initiative of the Council of the Federation since its founding in 2003. Starting in July 1995, with the passage of the Agreement on Internal Trade (AIT), reforms to address internal trade in Canada have been extensive. There are also ad hoc, bilateral agreements between individual provinces. For example, British Columbia and Alberta signed the Trade, Investment and Labour Mobility Agreement in April 2006. This expanded to include Saskatchewan in July 2010 with the New West Partnership Trade Agreement. A particularly interesting agreement addresses nonuniform trucking regulations: the Atlantic Agreement on Uniform Vehicle Weights and Dimensions in 2001. We use the variation in the timing of reforms to detect the effect on trade costs. Regressing bilateral trade costs on an indicator for whether the AIT was in effect, between 1992 and 1999, with trade pair fixed effects, we find internal trade costs are approximately 10% lower after the agreement.

Existing research on barriers to internal trade can be classified into two broad categories: gravity equation estimates and estimates using proxies for trade costs. The gravity equation research essentially regresses aggregate trade flows between regions on various observable determinants of trade, such as the partners' GDP, population, distance, language, etc., on an indicator variable for a national/state border lying between the partners. Examples of this work include Wolf (2000); Hillberry and Hummels (2003) and Yilmazkuday (2011) for the United States; Nitsch (2000) and Chen (2004) for the European Union; Poncet (2005) for China; and Requena and Llano (2010) for Spain. We provide trade cost

---

<sup>4</sup>See Beaulieu et al. (2003) for an excellent overview of the nature of interprovincial trade barriers in Canada, including many illuminating anecdotes that suggest significant costs arise from minor regulatory differences across provinces.

estimates in Section 3.1 based on these approaches. The literature using proxies for trade costs, such as price dispersion, sectoral output share convergence, or explicit measures of barriers is also enlightening. Chen (2004), for example, finds that explicit regulatory barriers - technical barriers to trade - significantly reduces trade between countries within the EU. The difficulty in measuring internal trade costs in this manner, though, is demonstrated by the starkly differing conclusions for China reached by Young (2000) and Holz (2009). We avoid some of these difficulties by estimating intra-national trade barriers using: (1) a flexible, micro-founded approach following Novy (2011); and (2) a model-based approach following Eaton and Kortum (2001, 2002). We further depart from the existing literature by addressing the productivity effects of internal barriers. Recently, work by Corcos et al. (2011) examines EU integration and internal trade frictions in France, finding substantial productivity gains from internal liberalization. Our results, which are based on an entirely different framework,<sup>5</sup> also suggest internal trade barriers reduces aggregate productivity and increases regional income inequality.

Our research also fits within an ongoing debate within Canada on the effects of barriers to internal trade. An oft-cited COMPAS poll produced in 2004 suggests business leaders consider remaining trade barriers to be serious, and hinder the development of the Canadian economy. Several case-based studies have also been undertaken. The Knox Report (2001) notes several examples of internal trade barriers. Beaulieu et al. (2003) provide an excellent overview of interprovincial trade policies and government reforms. Academic research assessing the impact of interprovincial trade barriers is limited and uses very different methodologies from this paper. Moreover, they rely on assumptions about demand elasticities and trade barriers. For instance, Whalley (1983) performs some back-of-the-envelope calculations by assuming uniform barriers of 10% across provinces and demand elasticities of 0.5, finding internal trade barriers cost only 0.13% of GDP. Using an Armington framework, Trela and Whalley (1986) find even smaller effects. We depart significantly from these attempts and have, we believe, the first systematic attempt to measure internal trade costs, the effectiveness of policy reforms, and the consequences for aggregate and regional productivity using high quality data and current new-trade methodologies from the international trade literature. Gains from trade in this class of models essentially follow from selection across firms: more productive firms can survive increased competition following an ease of import restrictions.

We next outline the geographic patterns of Canadian productivity and trade in Section 2. We estimate reduced-form measures of intra-national trade costs, based on existing gravity-model approaches and on Novy (2011), in Section 3. To determine the effect of changes in internal trade policy on Canadian productivity, we develop a detailed general equilibrium model following recent developments in the international trade literature, in Section 4. We calibrate the model, detail results, and estimate the productivity effects for various counterfactuals in Sections 5 and 6. We explore the effects of policy reform in Section 7. We conclude in Section 8.

---

<sup>5</sup>Their estimation and counterfactual simulations build on Melitz and Ottaviano (2008), whereas ours build on Eaton and Kortum (2002). The former requires firm-level data that is not readily available in Canada. The latter requires data on gross output, consumer expenditure, and trade flows for, and between, each province; a unique kind of dataset that is available for Canada. In addition, internal trade data for France was imputed.

## 2 Data and Key Patterns

### 2.1 Data

Following Eaton and Kortum (2001) and Bernard et al. (2003), we measure trade shares  $\pi_{ij}$  as the ratio of region- $i$  imports from region- $j$  relative to region- $i$ 's total consumer expenditure:  $\hat{\pi}_{ij} = M_{ij}/E_i$ . The Statistics Canada data we use is unique as it provides an internally consistent set of gross output, consumer expenditure, and intra-national trade data for a number of industries between 1997 and 2007.<sup>6</sup> Total expenditure consists of personal expenditure, capital formation and government expenditure, plus intermediate domestic demand (inputs into the production process), plus additions to inventory stocks of producers, wholesalers and retailers. It is equivalent to purchases from abroad (international imports), purchases from other provinces (interprovincial imports), and domestic purchases.

Distances are calculated in two ways: (1) as kilometers between capital cities; and (2) as the population-weighted average distance between Canadian cities. To calculate measure (1), we use the great-circle formula with longitude and latitude coordinates for each province's capital city. To calculate measure (2), we collect data from the Global Rural-Urban Mapping Project (GRUMP Version 1).<sup>7</sup> It contains data on 884 population centers in Canada, ranging from 7 in Prince Edward Island to 247 in Ontario. For each center, population data and longitude and latitude coordinates are provided. For each population center- $i$  we determine the distance to all other centers  $j$  using the great-circle formula. The population-weighted distance between center- $i$  in province- $h$  and all centers  $j$  in another province- $k$  is then given by  $\sum_{j \in k} d_{ij} \frac{p_j}{P_k}$ , where  $p_j$  is the population in area- $j$  and  $P_k$  is the population of province- $k$ . We then take the average within each province in a similar fashion to arrive at the population-weighted distance between provinces  $h$  and  $k$ ,  $d_{hk} = \sum_{i \in h} \frac{p_i}{P_h} \left( \sum_{j \in k} d_{ij} \frac{p_j}{P_k} \right)$ . This measures the distance between typical residents of two provinces and is in line with Helliwell and Verdier (2001) and Head and Mayer (2002). The advantage of this measure is it corrects for certain features of Canadian geography. For example, the populations of Quebec and New Brunswick are further apart, and Ontario and Quebec closer together, than the capital distances would suggest. Distance between a Canadian region and the United States (our proxy for the rest of the world) is always using method (1).

We obtain annual data on wages, employment, value-added (nominal and real), hours worked, and labour productivity for each province, by industry and year, from Statistics Canada.<sup>8</sup> These data are used in the next section to illustrate regional productivity differentials in Canada. We compare our model-implied measures of productivity (from Section 4) to actual data, and find the model matches well with data.

---

<sup>6</sup>CANSIM Table 3860002 - Interprovincial and international trade flows at producer prices.

<sup>7</sup>Center for International Earth Science Information Network (CIESIN), Columbia University; International Food Policy Research Institute (IPFRI), the World Bank; and Centro Internacional de Agricultura Tropical (CIAT), 2004. Global Rural-Urban Mapping Project (GRUMP): Settlement Points. Palisades, NY: CIESIN, Columbia University. Available at <http://sedac.ciesin.columbia.edu/gpw>. Accessed September 10th, 2011.

<sup>8</sup>CANSIM Table 3830011 - Labour productivity and related variables.

## 2.2 Patterns of Canadian Labour Productivity and Internal Trade

There are large differences in productivity across the Canadian provinces. For instance, in 2010 the average real value-added per hour was \$49.30 in Alberta, \$41.80 in Ontario, and \$31.40 in Prince Edward Island. These differences in productivity are reflected in wage payments to labour, which in PEI are only 60% of Alberta's average. These cross-province differences are also found within sectors. Consider manufacturing: labour productivity in Ontario is twice that in PEI. The differences with respect to other provinces are also large. Ontario's manufacturing sector is over 50% more productive than manufacturing in all the Maritime provinces, 50% higher than in Manitoba, and 20% higher than Quebec and BC. These differences lower overall Canadian productivity. At the margin, reallocating an hour of manufacturing labour from PEI to Ontario will increase Canadian GDP by \$27 (the difference in labour productivity). Internal barriers to trade, however, may inhibit this reallocation.

This pattern of large regional productivity differences in the tradable goods sectors holds broadly. To measure and decompose these differences, consider the variance of log value-added per hour for each province in goods versus services. In 2010 the variance in log labour productivity is 0.042 overall, but is 0.126 in the goods sectors and only 0.021 in services. Given that goods production accounts for roughly 30% of business sector employment in Canada, the fact that labour productivity differences are three times larger than average in these sectors is important. In fact, if there were no cross-province differences in goods-sector labour productivity, then overall productivity differences in Canada would fall to one-quarter of their current size. This might add significantly to aggregate productivity and overall living standards. We quantify provincial trade barriers, and the gains from their removal, through counterfactual simulations within a general equilibrium model of trade in Sections 5 and 6.

The data on internal trade flows also reveals important patterns: (1) the volume of interprovincial trade is nearly as large as Canada's international trade volume; and (2) the relative importance of interprovincial trade is decreasing in a province's productivity. Figure 1 displays the ratio of the total internal volume of trade (imports plus exports) to trade volumes with international destinations. Overall, this ratio is very close to one and is generally larger for poorer provinces. For example, Ontario's trade with the rest of Canada is 44% of its trade with international partners while the poorer provinces, such as PEI and Manitoba, have higher trade with other Canadian provinces than with the world - 85% and 11% higher, respectively. These patterns are also stable through time. More formally, we regress the internal trade ratio on each province's  $\log(\text{GDP}/\text{Worker})$ , with year controls. We find that a 10% higher level of labour productivity is associated with a 14 percentage point lower ratio of internal to external trade. Internal trade appears to be disproportionately more important for poor provinces.

### 3 Reduced-Form Trade Cost Estimates

In this section we provide estimates of internal trade costs that do not rely on the model structure developed in Section 4. We begin by illustrating a standard approach from the gravity-equation literature and proceed to estimate a new technique developed by Novy (2011).

#### 3.1 Standard Estimates from Gravity Literature

Existing work on internal trade barriers, such as Wolf (2000) for the United States, estimate how much sub-national regions trade with each other relative to similarly sized regions in another country. The estimates range from approximately 5 for the US and over 20 for the European Union (see, e.g., Head and Mayer, 2000; Wolf, 2000). These imply that US states are nearly 5 times more likely to trade with each other than an observationally similar region in another country. One can derive tariff-equivalent expressions of these trade costs with an assumption about the magnitude of cost-elasticities of trade. While we leave a more detailed discussion of this elasticity until Section 5.2, let us for now assume a value of 8, which is within the range found by Anderson and van Wincoop (2004). This implies that internal trade costs in the United States are approximately 20% (given by  $e^{\ln(4.39)/8} - 1$ , where 4.39 is the border effect in Wolf, 2000).<sup>9</sup> For the EU, this figure is closer to 45%.

We estimate internal trade costs for Canada by following these procedures. Assume prices ( $p$ ) in an importing province ( $i$ ) for a good produced in province ( $j$ ), which is a given distance ( $d$ ) away, are given by  $p_{ij} = (1 + u)d_{ij}^{\delta}p_j$ , where  $u$  reflects the internal trade barriers and  $\delta$  is the distance-elasticity of trade costs. Assume trade flows from province- $i$  to province- $j$ , denoted  $x_{ij}$ , depends on their relative GDP and prices. Given a cost-elasticity of trade, denoted  $\theta$ , and by normalizing by each province's domestic absorption,<sup>10</sup> one can estimate

$$\ln\left(\frac{x_{ij}}{x_{ii}}\right) = \beta_1 \ln\left(\frac{y_j}{y_i}\right) + \beta_2 \ln\left(\frac{d_{ij}}{d_{ii}}\right) + \beta_3 \ln\left(\frac{p_j}{p_i}\right) + \beta_4 \ln(1 + \delta) + \varepsilon_{ij},$$

where  $y$  is GDP and  $w$  is wages,  $d_{ij}$  is the distance between province- $i$  and province- $j$ ,  $d_{ii}$  is the internal distance of province- $i$ , and  $\delta$  is the internal trade cost facing cross-border trade flows.

Standard theory makes clear predictions for this relationship: trade is increasing in the relative GDP of the partner ( $\beta_1 = 1 > 0$ ), decreasing in the relative distance between them ( $\beta_2 = -\delta\theta < 0$ ), and decreasing in the relative price of the partner ( $\beta_3 = -(1 + \theta) < 0$ ). The internal trade costs will be captured by the constant term, where  $\beta_4 = \theta$ . For a given cost-elasticity of trade, the internal trade costs can be estimated as  $\exp(-\text{constant}/\theta) - 1$ . Given limitations

<sup>9</sup>Hillberry and Hummels (2003) use more detailed data than Wolf (2000), arguing that certain contracting practices of manufacturers and wholesalers can account for much of the state-border effect in the United States. By their estimate, the border effect is 1.55. This implies an internal trade cost of 6% if we abstract from the source of the localized wholesaler activity as a form of trade cost.

<sup>10</sup>This follows Head and Mayer (2000); Poncet (2005) and others, and eliminates third-party effects. The normalized trade trade between Alberta and British Columbia, for example, is not affected by trade between BC and Ontario since BC's domestic absorption exactly offsets any change in the actual trade between Alberta and BC due to BC and Ontario.

in the data, we use relative wages to proxy for relative prices (following Poncet (2005), which implicitly assumes real wages equalize across provinces). Estimating this expression, we find that internal trade costs in Canada are approximately 36% and display little time variation between 1997 and 2007. One can also estimate a province-specific trade cost,  $\delta_i$ . We find that this cost varies from 15% in Ontario and Alberta to nearly 50% for the Atlantic provinces. We go beyond this approach with a recently developed and more flexible approach presented in the next subsection and a model-based measure presented in Section 4.

### 3.2 A Flexible, Micro-Founded Measure of Interprovincial Trade Costs

An extensive literature has recently developed based on new micro-founded international trade models. It is well known that these models - and, indeed, any reasonable model of international trade - imply similar gravity relationships between bilateral trade flows. Equivalent gravity relationships hold under Armington assumptions, such as in Anderson and van Wincoop (2003); monopolistic competition, as in Redding and Venables (2004); heterogeneous firm-level models, such as Melitz (2003); Melitz and Ottaviano (2008) and Chaney (2008); or Ricardian models, as in Eaton and Kortum (2002). Novy (2011) demonstrates that the leading variations in modern trade theories yield gravity relationships that depend on trade costs between bilateral pairs and separate source- and destination-specific characteristics. This feature has recently been successfully exploited to estimate trade costs with minimal structure or assumptions by Jacks et al. (2008, 2010, 2011).

In brief, with more detailed coverage and examination provided by Novy (2011), all trade models have similar implications for the determinants of trade,  $x_{ij}$ , between region- $i$  and region- $j$ . Consider the following variations, where exports are denoted by  $x_{ij}$  and trade costs by  $t_{ij}$ :

- Preference-Based:  $x_{ij} = \frac{y_i y_j}{\sum_j y_j} \left( \frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma}$
- Ricardian:  $x_{ij} = \frac{T_i(c_i t_{ij})^{-\theta}}{\sum_{l=1}^J T_l(c_l t_{lj})^{-\theta}} y_j$
- Firm Heterogeneity:  $x_{ij} = \mu \frac{y_i y_j}{\sum_j y_j} \left( \frac{w_i t_{ij}}{\lambda_j} \right)^{-\gamma} f_{ij}^{-\left(\frac{\gamma}{\sigma-1}-1\right)}$
- Endogenous Markups:  $x_{ij} = \frac{1}{2\delta(\gamma+2)} N_i^E \psi_i L_j \left( c_j^d \right)^{\gamma+2} t_{ij}^{-\gamma}$

Beyond exports and trade costs, the other variables are not important for our purposes, so we leave them undefined. Minor manipulations of any of the above will cancel all terms except the trade flow variables. To illustrate with the Ricardian framework, first take the product of the trade flows in both directions between region- $i$  and region- $j$ ,

$$x_{ij} x_{ji} = \frac{T_i(c_i t_{ij})^{-\theta}}{\sum_{l=1}^J T_l(c_l t_{lj})^{-\theta}} \frac{T_j(c_j t_{ji})^{-\theta}}{\sum_{l=1}^J T_l(c_l t_{li})^{-\theta}} y_j y_i.$$



The product of spending on own-output by region- $i$  and region- $j$  is

$$x_{ii}x_{jj} = \frac{T_i(c_it_{ii})^{-\theta}}{\sum_{i'=1}^J T_{i'}(c_{i'}t_{i'})^{-\theta}} \frac{T_j(c_jt_{jj})^{-\theta}}{\sum_{i'=1}^J T_{i'}(c_{i'}t_{i'})^{-\theta}} y_i y_j.$$

The ratio of the above two expressions,  $\frac{x_{ij}x_{ji}}{x_{ii}x_{jj}} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^\theta$ , provides a measure of average between-region trade costs. It is helpful to define

$$\tau_{ij} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2\theta}} - 1, \quad (1)$$

where  $\tau_{ij}$  is the geometric average between-province trade cost,  $x_{ij}$  is the export volume from province- $i$  to province- $j$ ,  $x_{ii}$  is the output of province- $i$  produced for own consumption, and  $\theta$  captures the variation in productivity across heterogeneous firms (low  $\theta$  implies greater productivity variation). Notice that for  $i = j$ ,  $\tau_{ij} = 0$ , which means this measure of trade costs reflects the cost of trade *over and above* any internal distribution costs for each province. That is, it only measures the between-province component of trade costs.

With the data for trade flows ( $x_{ij}$ ) and gross output consumed domestically ( $x_{ii}$ ), described in Section 2.1, and by setting  $\theta = 8$  as before, we can determine bilateral trade costs,  $\tau_{ij}$ . We plot the average trade cost across bilateral trade pairs in Figure 2 for 2005. Figure 3 displays the time patterns for each province. We report trade costs between all bilateral pairs for 2005 in Table 3.

Bilateral trade costs inferred with this method do not purely reflect policy barriers to trade but also include factors such as distance. British Columbia and Nova Scotia, for example, will have high trade costs between each other due to their large geographic distance (over 4,000 kilometers). In order to estimate bilateral costs that exclude geographic distance, we assume the distance-elasticity of trade is 0.3.<sup>11</sup> Trade costs excluding distance effects is given by  $\tilde{\tau}_{ij} = \tau_{ij}/(d_{ij}/d_{ii})^{0.3}$ . We plot these estimates next to the main estimates in Figure 2. On average, weighted by provincial production volumes, internal trade costs in Canada are 30% (simple average of 38%).

Unfortunately,  $\tau_{ij} = \tau_{ji}$  by construction and provides no information, for example, on whether Quebec is more restrictive than Ontario for trade between these two provinces. To translate these trade costs into a province-specific import barrier, one that we can adjust in counterfactual experiments to quantify productivity gains from internal trade, we require more structure be placed on the data. To that end, we develop a detailed model in Section 4.

---

<sup>11</sup>This assumption is consistent with the distance-elasticity of freight rates from Hummels (1999), and it is also used by Alvarez and Lucas (2007). Using our trade cost estimates and internal distance measures, regressing  $\ln(\tau_{ij})$  on  $\ln(d_{ij}/d_{ii})$  and a constant yields a coefficient on distance of 0.28.

## 4 Ricardian Model of Provincial Trade Flows

In order to assess the productivity effects from reductions of internal trade barriers, and to estimate province-specific import barriers, we build on the general equilibrium, Ricardian trade model of Eaton and Kortum (2002) and Alvarez and Lucas (2007). The environment is composed of  $N$  regions of size  $L_i$ , 10 of which will be treated as Canadian provinces and one region representing the United States (as a proxy for the rest of the world). Each region can produce two types of goods: (1) *tradable* intermediate goods, a continuum of which can be produced with constant-returns to scale technologies; and (2) *nontradable* final output, which is produced with labour and a composite of the tradable intermediates. The composite intermediate good is assembled in each region with a CES aggregate of individual intermediate varieties, which are either produced locally or purchased from another region through trade. Trade in intermediate goods is motivated by productivity differences across regions and inhibited by trade costs between regions. Agents derive utility only from the consumption of final output. Each agent also allocates one unit of labour inelastically to either final output or intermediates production. Labour is the only productive factor. Finally, a government sector taxes labour and reallocates revenues in a lump sum to all residents in Canadian regions. The details of the model follow.

### 4.1 Production Technologies, Equilibrium Prices, and Trade Patterns

Final output ( $Y$ ) in region- $i$  is produced with a Cobb-Douglas technology using labour and an intermediate-goods aggregate,

$$Y_i = s_i^\alpha q_i^{1-\alpha}.$$

Labour used in the production of final goods in region- $i$  is denoted  $s_i$  as a mnemonic to reflect the nontradable services component in final output, and  $\alpha$  is labour's share of final output. The intermediate goods aggregate,  $q_i$ , is produced using a CES aggregation of individual varieties with an elasticity of substitution  $\rho$ ,

$$q_i = \left[ \int_0^1 q_i(z)^{\frac{\rho-1}{\rho}} dz \right]^{\frac{\rho}{\rho-1}},$$

where  $q_i(z)$  denotes the amount of intermediate variety- $z$  used in region- $i$  for the production of the aggregate intermediate good  $q_i$ .

Individual product varieties are produced with a Cobb-Douglas technology also using labour and an intermediate goods aggregate,

$$q_i(z) = A_i(z) l_i(z)^\beta q_i^{1-\beta},$$

where  $A_i(z)$  is the productivity for variety- $z$  in region- $i$  and  $l_i(z)$  is the labour input used for variety- $z$ . The market for each variety is contestable with zero barriers to firm entry or exit. Any price deviation from marginal cost will result in a new entrant supplanting the incumbent firm. This implies producer prices will equal marginal costs,  $\frac{w_i^\beta P_i^{1-\beta}}{A_i(z)}$ , where  $w_i$  denotes wages in region- $i$  and  $P_i$  is the price of the intermediate aggregate.

Individual varieties of the tradable intermediate may be produced within region- $i$  or imported from another region, depending on which option is cheapest given trade costs. Trade costs are iceberg:  $\Delta_{ij}$  goods are shipped per unit imported by region- $i$  from region- $j$ . To avoid shipments through third-party regions, the triangle inequality holds:  $\Delta_{ij} < \Delta_{ih}\Delta_{hj}$ , for any region- $h$ . Given transport costs, the price of variety- $z$  in region- $i$  is the lowest price charged by any possible producer; that is,

$$p_i(z) = \min_{j \in \{1, \dots, N\}} \Delta_{ij} \frac{w_j^\beta P_j^{1-\beta}}{A_j(z)}. \quad (2)$$

Given the CES aggregation forming the composite intermediate good, the price index for  $q_i$  is  $P_i = \left[ \int_0^1 p_i(z)^{1-\rho} dz \right]^{1/(1-\rho)}$ . To derive an expression for individual variety prices, and therefore the intermediate good's price index, a particular distribution of firm productivity is required. Specifically, we assume they are independent random draws from a Fréchet distribution specific to each region- $i$ ,<sup>12</sup> such that

$$Pr(A_i(z) \leq x) = F_i(x) = e^{-(x/A_i)^\theta},$$

where  $\theta$  governs productivity dispersion and  $A_i$  is the overall level of productivity in each region- $i$ , with  $A_i \propto E[A_i(z)]$ .<sup>13</sup> Lower  $\theta$  implies greater variability in productivity across firms (and regions) and higher  $A$  implies greater average productivity. The parameter  $\theta$  is also the cost-elasticity of trade in the model and is similar to the elasticity introduced in previous sections. These productivity differences across producers provide the incentive to trade: low-productivity producers in region- $i$  may be shut down in favour of an import. The incentive to trade, and the gain from doing so, is inversely related to  $\theta$ . The assumption of a Fréchet productivity distribution implies

$$P_i = \gamma \left[ \sum_{j=1}^N \left( \frac{\Delta_{ij} w_j^\beta P_j^{1-\beta}}{A_j} \right)^{-\theta} \right]^{-1/\theta}, \quad (3)$$

<sup>12</sup>The Fréchet distribution is a natural choice for a number of reasons. Any underlying distribution of firm productivity that follows a power law (such as Pareto, student's  $t$ , lorentzian, log gamma, and double Pareto, to name a few) will converge to a Fréchet distribution. There is much evidence that firm size in the United States closely follows a Pareto distribution (see, e.g., Axtell (2001)). There are also strong theoretical reasons to expect the underlying distribution of ideas, in the specific sense of Jones (2005), follows a Pareto distribution. Jones (2005) demonstrates that, with this distributional assumption, Leontief plant technologies aggregate to Cobb-Douglas production with labour-augmenting technical change. Kortum (1997) demonstrates that a Pareto distribution of underlying ideas is required for exponential growth in such a model.

<sup>13</sup>The constant of proportionality is  $\Gamma[1 - \frac{1}{\theta}]^{-1}$ . This relates to the scale parameter of a Fréchet distribution,  $\lambda_i = A_i^\theta$ .

where  $\gamma = \Gamma\left(1 + \frac{1-\rho}{\theta}\right)^{\frac{1}{1-\rho}}$  and  $\Gamma$  is the gamma function.<sup>14</sup> Notice equation (3) is the price paid by final output producers in region- $i$  for the composite intermediate good  $q_i$  and no knowledge of which region produced a given variety is necessary.

The share of region- $i$  expenditures purchased from region- $j$  depends on the fraction of varieties produced in region- $j$  that have the lowest price of all producers in any other region, from the perspective of region- $i$  consumers. This share is given by

$$\pi_{ij} = \frac{\Psi_{ij}}{\sum_{j=1}^N \Psi_{ij}}, \quad (4)$$

where  $\Psi_{ij} = \Delta_{ij}^{-\theta} \left(\frac{A_j}{w_j^\beta P_j^{1-\beta}}\right)^\theta$  is the product of trade costs and competitiveness of region- $j$  from the perspective of region- $i$  consumers. A region's competitiveness is defined by  $\frac{A_j}{w_j^\beta P_j^{1-\beta}}$ , which rises with technological productivity  $A_j$  and falls with unit costs  $w_j^\beta P_j^{1-\beta}$ .

## 4.2 Equilibrium Wages, Trade Balance, and the Government Budget

We depart from the typical formulation of the Eaton and Kortum (2002) and Alvarez and Lucas (2007) models by explicitly incorporating a tax and transfer system, appropriate in the Canadian context, to generate persistent trade imbalances across provinces. Poor provinces have significant trade deficits with the rest of Canada and neglecting this feature would affect our model's productivity estimates.

The government raises revenue through a proportional tax on labour income, at rate  $t$ , and distributes it at a fixed amount per person,  $m$ . This feature is meant to capture much of the trade deficits observed for Canadian provinces and the internal fiscal redistribution undertaken by the federal government. The government budget must balance in each period, with total income tax revenue equaling total per capita disbursements. That is,

$$\sum_{i \in \mathbb{C}} w_i L_i t = \sum_{i \in \mathbb{C}} m L_i,$$

which requires  $m = \sum_{i \in \mathbb{C}} \left(\frac{L_i}{L}\right) w_i t$ , where  $\mathbb{C}$  denotes regions within Canada. For international regions, where  $i \notin \mathbb{C}$ ,  $t = m = 0$ .

The value of spending on tradable goods by region- $i$  is

$$L_i P_i q_i = \frac{1-\alpha}{\beta} [L_i (w_i (1-t) + m)].$$

---

<sup>14</sup>As  $1 + \theta > \rho$  must hold for a well defined Gamma-function, we set  $\rho$  such that  $\gamma = 1$ .

The same will hold for region- $j$ , which will allocate  $\pi_{ji}$  fraction of its spending to output from region- $i$ . Total output of region- $i$ 's tradable sector equals total demand, from all sources. Given labour's share of output in tradables is  $\beta$ ,  $w_i l_i = \beta P_i q_i$ . So, supply,  $P_i q_i$ , equaling demand,  $\frac{1-\alpha}{\beta} \sum_{j=1}^N [L_j (w_j(1-t) + m) \pi_{ji}]$ , implies

$$\frac{w_i l_i}{\beta} = \frac{1-\alpha}{\beta} \sum_{j=1}^N [L_j (w_j(1-t) + m) \pi_{ji}].$$

Since the equilibrium share of labour in final output is  $\alpha$ ,  $l_i = L_i(1 - \alpha)$ , and equilibrium wages satisfy

$$w_i L_i = \sum_{j=1}^N [L_j (w_j(1-t) + m) \pi_{ji}]. \quad (5)$$

Region- $i$ 's trade deficit is given by the difference between imports,  $\frac{1-\alpha}{\beta} [L_i (w_i(1-t) + m)] (1 - \pi_{ii})$ , and exports,  $\frac{1-\alpha}{\beta} \sum_{j \neq i} [L_j (w_j(1-t) + m) \pi_{ji}]$ . This reduces to

$$D_i = \frac{1-\alpha}{\beta} L_i [m - w_i t],$$

where  $D_i$  is the trade deficit of region- $i$ . If  $w_i t = m$ , imports equal exports. If  $w_i t < m$ , as is likely for poor regions, a trade deficit exists. This pattern of deficits across regions with different income levels is clear in the Canadian context and will be used to set the value of  $t$ . One can think of this as the capital inflow from net government transfers, which allows for a current account deficit.

## 5 Calibrating the Model

Trade costs, productivities, and labour income taxes are calibrated to match internal trade data. Trade costs ( $\tau_i$ ) and competitiveness ( $\frac{A_i}{w_i^\beta P_i^{1-\beta}}$ ) are selected to minimize deviations between model-implied and actual trade shares. Essentially, fixed effects in a particular regression specification implied by the model identify these values. Income taxes,  $t$ , (and implicitly lump-sum transfers,  $m$ ) are selected to match trade balance data by province. Trade costs and competitiveness determine trade shares and prices from equations (3) and (4), with equilibrium wages for each region solving equation (5). Provincial productivities ( $A_i$ ) are then given by the product of competitiveness and unit costs,  $w_i^\beta P_i^{1-\beta}$ . Other parameters of the model ( $\beta$ ,  $\alpha$ ,  $\theta$ ,  $L_i$ ) are fixed to match either observable moments in the data or well established empirical relationships. The parameters, and their resulting values, are reported in Table 1.

Table 1: Model Parameters to Calibrate

Parameters	Target	Value
$\theta$	Cost-Elasticity of Trade Flows	8
$L_i$	Employment Data	<i>Region-Specific</i>
$\{A_i, \tau_i\}$	Bilateral Trade Shares	<i>Region-Specific</i>
$t$	Provincial Trade Deficits	0.095
$\alpha$	Labour's Share of Final Output	0.7
$\beta$	Value-Added to Gross-Output Ratio	0.35

## 5.1 Parameters to Match Trade Data

To begin, divide the share of expenditure region- $i$  spends on imports from region- $j$  by region- $i$ 's home share, to arrive at

$$\frac{\pi_{ij}}{\pi_{ii}} = \frac{\psi_{ij}}{\psi_{ii}} = \frac{\Delta_{ij}^{-\theta} T_j^\theta}{T_i^\theta},$$

which implies

$$\ln\left(\frac{\pi_{ij}}{\pi_{ii}}\right) = \theta \ln(T_j) - \theta \ln(T_i) - \theta \ln(\Delta_{ij}). \quad (6)$$

The above equation means the expenditure share of region- $i$  to output from region- $j$  (relative to region- $i$ 's share to itself) depends on: (1) the exporter's competitiveness,  $T_j$ ; (2) its own competitiveness,  $T_i$ ; and (3) the trade costs between them,  $\Delta_{ij}$ . We assume trade costs are composed of a region-specific policy-component,  $\tau_i$ , and a bilateral geographic-component,  $\delta_{ij}$ , such that  $\Delta_{ij} = \tau_i \delta_{ij}$ . We will consider the policy component,  $\tau_i$ , as applying only to imports from other Canadian provinces. Frictions affecting international trade flows will be captured within  $\delta_{ij}$ . We further assume that geographic costs depend on: (1) the distance between source and destination regions; and (2) whether the two regions share a direct border. Specifically,

$$\ln(\Delta_{ijt}) = \delta \ln(d_{ij}) + b + \ln(\tau_{it}) + v_{ijt},$$

where  $\delta$  is the effect of distance  $d_{ij}$ ,  $b$  is the effect of sharing a border, and  $v_{ijt}$  captures all other factors.<sup>15</sup> Substitute the above into equation (6) to arrive at

$$\ln\left(\frac{\pi_{ijt}}{\pi_{iit}}\right) = \theta \ln(T_{jt}) - \theta \ln(T_{it}) - \theta \beta \ln(d_{ij}) - \theta b - \theta \ln(\tau_{it}) - \theta v_{ijt}. \quad (7)$$

We estimate the above expression with OLS, importer and exporter fixed effects, and no constant term. Let  $\hat{\eta}_i$  be

<sup>15</sup>Henderson and Millimet (2008), using nonparametric methods, find no consequence from assuming an identical trade-cost response across trade partners nor in assuming log-linear trade cost function.

the exporter fixed effect estimate for region- $i$ , which will capture its competitiveness,  $T_i$ . Let  $\hat{l}_i$  be the importer fixed effect estimate for the same region, which will capture both the destination region's competitiveness,  $T_i$ , and the province-specific policy-related import cost,  $\tau_i$ . Using information from the destination's competitiveness for observations when it was an exporter, we purge the importer fixed-effect of the importer competitiveness, leaving only the policy barrier. Specifically,  $\hat{T}_i = e^{\hat{\eta}_i/\theta}$  and  $\hat{\tau}_i = e^{-(i+\hat{\eta}_i)/\theta}$ . We allow competitiveness and policy trade costs to vary across years but restrict  $\delta$  and  $b$  to be time invariant. Given our specification, and given our data does not disaggregate by source or destination any trade flow between a Canadian province and another country abroad, we will not be able to separately identify an international border cost or distinguish between tariffs and productivity abroad. That is, a high Canadian barrier to international imports is not distinguishable from low productivity abroad. For our purposes, this is inconsequential.

We estimate equation (7) using data from 1997 to 2007. The results of the regression are provided in Table 4. Overall, it matters little what estimate of distance is used - both find a distance-elasticity of trade of approximately -1.18. This is very close to standard estimates from the international trade literature. The fit of the model trade shares to actual bilateral trade shares is displayed in Figure 6. We report provincial fixed effects, and tariff-equivalent trade costs, expressed relative to the average province, in Table 5. Values are normalized relative to the average Canadian province. We use Figure 4 to illustrate a comparison between the model-implied estimates and those derived from the flexible approach of Section 3.2. That these two alternative forms of estimation yield similar results increases confidence in our model-based measure. Figure 5 displays the time patterns of trade costs for each province. We find the model-based measure of province-specific trade costs is stable through time - consistent with estimates using the flexible approach. The provincial productivity implied by the model are compared to data in Figure 7 - the model fit is fairly good, despite not targeting productivity data.

Finally, labour income taxes are selected to minimize the sum of squared deviation between model-implied trade deficits and actual deficits in the data. A tax rate of 9.5% matches the data well, with the exception of Alberta and Newfoundland and Labrador, where surpluses due to oil exports are not captured by the model. Figure 8 plots the fit of the model-implied trade deficits to data. For comparison, approximately 3.4% of Canada's 2011 GDP is allocated by the federal government to the provincial governments through various transfer programs, representing nearly \$1,700 per capita. These transfers are tilted towards poorer provinces, with Alberta receiving approximately \$900 per capita and Prince Edward Island receiving over \$3,400. Expressed another way, the \$1,700 transfer represents roughly 3% of the average annual earnings in Ontario (roughly \$30/hour for 1800 hours). In comparison, the model transfer value represents just over 7% of the average Ontario annual wage earnings. To make up the difference, consider other policies beyond these inter-governmental transfers. The federal government directly supports residents and businesses in poorer provinces, through programs such as the Atlantic Development Fund, the Economic Development Agency of Canada for the Regions of Quebec, or special Employment Insurance measures for high unemployment regions. Other

transfers to persons through the federal government - such as the Canada Pension Plan - are also comparable to our model transfer,  $m$ . For simplicity, we maintain a constant per capita transfer and a uniform flat tax on income.

## 5.2 Other Model Parameters

Given perfectly competitive input and output markets, the ratio of value-added to gross-output will equal labour's share of output,  $\beta$ . Using data from the United Nations Industrial Development Organization (UNIDO), this ratio is 0.35 for all Canadian manufacturing industries and is stable across time. We set  $\beta = 0.35$ . To set a value for  $\alpha$ , we use the fraction of employment in nontradables (services), 70%. This compares well with a number of alternative estimates outlined by Alvarez and Lucas (2007). For instance, the share of value-added in nontradable sectors also equals  $\alpha$  in the model and this share averages 70% in OECD economies. The share of value added in tradable industries for Canada in 2007 using UNSD National Accounts (and ISIC A through D) is 40%, suggesting  $\alpha = 0.6$ . Given that aggregate productivity gains from trade are decreasing in  $\alpha$ , our choice of  $\alpha = 0.70$  is likely conservative.

The parameter  $\theta$ , which governs the productivity dispersion across producers within (and between) regions, also determines how sensitive trade flows are to trade costs (higher  $\theta$  implies a *lower* cost-elasticity of trade flows). This parameter is the subject of much research. Alvarez and Lucas (2007) set  $\theta = 6.67$ , Eaton and Kortum (2002) set  $\theta = 8.3$ , Waugh (2010) finds  $\theta = 7.9$  for OECD countries and  $\theta = 5.5$  for non-OECD countries, and for colonial India Donaldson (2010) finds  $\theta = 3.8$  for 17 agriculture varieties and  $\theta = 5.2$  for 85 commodities. Using plant-level data, Bernard et al. (2003) find  $\theta = 3.6$ . Using wages and trade, Eaton and Kortum (2002) find  $\theta = 3.6$ . Anderson and van Wincoop (2004) review the literature and argue a value for  $\theta$  between 5 and 10 is reasonable. Using a new estimator and disaggregated price and trade data, Simonovska and Waugh (2011) find  $\theta = 4.1$ , with a range between 2.5 and 5.5. Gains from trade, and the trade cost estimates themselves, are increasing in  $\theta$ ; we thus feel  $\theta = 8$  is conservative.

## 6 The Gains from Internal Trade

One can change import barriers,  $\tau_i$ , and re-estimate regional wages and trade patterns using equations (5) and (4), with prices given by equation (3). Since producers are competitive, all operating firms have an identical intermediates to labour ratio and changes in labour productivity can be derived from changes in real wages. One can show that labour productivity in tradables is

$$\frac{q_i}{l_i} = \pi_{ii}^{-\frac{1}{\beta\theta}} A_i^{\frac{1}{\beta}}, \quad (8)$$

which increases with technical productivity and decreases with the fraction of varieties produced at home. Aggregate labour productivity, since tradables is only  $1 - \alpha$  of final goods, is proportional to  $\left(\frac{q_i}{l_i}\right)^{1-\alpha}$ . Thus, the percentage



Table 2: Impact of Various Counterfactual Experiments on Productivity

Counterfactual Experiment	Change in Productivity (%)				Change in Cross-Province Productivity Variation (%)
	Aggregate Economy		Tradable Sector		
	<i>Canada</i>	<i>Median Province</i>	<i>Canada</i>	<i>Median Province</i>	
Lower Internal Barriers by 50%	2.7	4.8	9.0	16.0	-17.9
Eliminate Internal Barriers	8.3	15.6	27.8	52.0	-43.5
Frictionless Internal Trade	19.5	57.0	64.9	189.9	-92.1
Eliminate Internal Bilateral Asymmetries	1.1	3.2	3.5	10.7	-36.4
Uniform Barriers at Ontario's Level	0.4	1.1	1.2	3.7	-10.6
Internal Autarky	-1.2	-1.8	-4.1	-6.1	5.0
Complete Autarky	-3.8	-3.9	-12.6	-13.1	7.2
Lower International Barriers by 20%	7.6	5.2	25.2	17.4	6.1

Displays the change in labour productivity for the aggregate economy and for the tradable sector following various counterfactual experiments. We display the national average change (GDP weighted provincial average) and the median change across provinces. The change in the variation of productivity across provinces is measured as the percentage change in the variance of log productivity.

increase in tradables and aggregate productivity can be estimated directly from counterfactual changes in  $\pi_{ii}$ . Specifically, we have  $\frac{\partial \ln(q_i/l_i)}{\partial \ln(\pi_{ii})} = -(\beta\theta)^{-1}$  for tradables and  $\frac{\partial \ln(Y_i/L_i)}{\partial \ln(\pi_{ii})} = (1 - \alpha) \frac{\partial \ln(q_i/l_i)}{\partial \ln(\pi_{ii})} = -(1 - \alpha)(\beta\theta)^{-1}$  in aggregate. This holds across a broad range of models, as demonstrated by Arkolakis et al. (2009).

To illustrate, consider a policy change that decreases the fraction of tradable goods produced individually by each province for their own consumers by 10%. This increases average productivity since each province will produce fewer, relatively higher productivity, varieties at home. This has a direct effect on sectoral average productivity, an effect captured by  $1/\theta$ , and an indirect effect since tradables are intermediate inputs, an effect captured by  $1/\beta$ . The combined effects of the 10% reduction in a province's home-share on productivity would be  $(10/\beta\theta)\%$  for tradables and  $(1 - \alpha)(10/\beta\theta)\%$  in aggregate. Given the parameter values we select for the baseline model, tradables productivity would increase by nearly 3.5% and aggregate productivity by just over 1%. We now turn to various counterfactual experiments.

## 6.1 Counterfactual Experiments

To derive counterfactual productivity by province, we solve for prices, trade shares, and wages using equations (3) and (4), such that equation (5) holds, with a new value for each  $\Delta_{ij} = \tilde{\tau}_i \delta_{ij}$  for some counterfactual provincial import cost  $\tilde{\tau}_i$ . Since the model-based method estimates only relative trade costs, not levels, we use in these exercises the levels from the flexible method. Given the new equilibrium trade shares,  $\pi_{ii}$ , for each province, we use equation (8) to back out the new implied labour productivity. We provide estimates of the productivity impact and the resulting change in variation in aggregate productivity across provinces. Table 2 summarizes our findings.

## Internal Trade Cost Reductions

We begin by lowering province-specific import costs applied to exports from other Canadian provinces (not from abroad) by 50%. That is, let  $\tilde{\Delta}_{ij} = \Delta_{ij}/(1 + 0.5\bar{\tau}_i)$  for all  $i \in \mathbb{C}$ , where  $\bar{\tau}_i$  is the average trade cost for province- $i$  using the flexible method in Section 3.2. Productivity grows by approximately 9% nationally in tradable goods, but disproportionately due to dramatic productivity growth in poor provinces. The median province experiences an increase in tradables productivity of 16%. In aggregate, productivity increases by 2.7% for Canada as a whole and by nearly 5% for the median province. When internal trade costs are completely eliminated, by setting  $\tilde{\Delta}_{ij} = \Delta_{ij}/(1 + \bar{\tau}_i)$  for all  $i \in \mathbb{C}$ , productivity rises by over 8% nationally - approximately half the gap between Canada and the United States - and by over 15% for the median province. Figures 9 and 10 illustrate the two counterfactuals for all provinces, in aggregate and for tradables. The aggregate labour productivity gains for various alternative reductions in the province-specific import costs are plotted in Figure 11.

Since poor provinces disproportionately gain from improved internal trade, regional income and productivity differences fall with liberalization. The variance of log productivity across provinces declines by nearly 18% when internal trade costs fall by 50%. For larger reductions in trade costs, the effects are more dramatic. Eliminating trade costs reduces productivity variation by over 40%. The large productivity (and, therefore, living standard) differences across provinces can be significantly reduced with more liberal internal trade policies.

The final liberalization experiment involves completely frictionless trade within Canada. This would remove from the model all sources of trade frictions between provinces, including distance. We re-solve the model with  $\tilde{\Delta}_{ij} = 1$  for all  $(i, j) \in \mathbb{C}^2$ . International trade costs remain, as in the baseline case. This is clearly not an achievable policy goal but does effectively illustrate the behaviour of the model and the magnitude of the *greatest possible* gains. We find national aggregate productivity would increase by almost 20% in this experiment and between-province productivity variation would be almost completely eliminated. This experiment illustrates that removing between-province trade barriers as measured by  $\bar{\tau}_i$  - which is an achievable policy goal - can achieve almost half of greatest possible gains from completely frictionless trade.

## Policy Harmonization

Following the insight of Waugh (2010) for trade costs between countries, we estimate the gains from removing bilateral asymmetries in trade costs. To illustrate, consider our estimate of trade costs between British Columbia and Alberta. We find BC's purchases of goods from Alberta cost 40% more than the producer's price while Alberta's purchases from BC cost close to 34% more. That is, we estimate  $\Delta_{BC,AB} = 1.4030$  while  $\Delta_{AB,BC} = 1.3368$ . If policies in Alberta and BC were identical with respect to inter-provincial trade, then these two trade cost estimates ought to be identical. We estimate the gains from eliminating all bilateral asymmetries by setting  $\tilde{\Delta}_{ij} = \min(\Delta_{ij}, \Delta_{ji})$  for all trade pairs within

Canada. Productivity gains are 1% in aggregate for Canada as a whole and the median province gains over 3%. Productivity variation across provinces falls by over one-third.

Alternatively, we can focus on uniform policy-related barriers. Ontario's province-specific trade cost,  $\bar{\tau}_{ON}$ , is the lowest in Canada. If we set  $\tilde{\Delta}_{ij} = [(1 + \bar{\tau}_{ON})\Delta_{ij}]/(1 + \bar{\tau}_i)$  then we can estimate the gains from an alternative form of policy harmonization. We find more modest gains, with aggregate productivity rising nationally by 0.4% and productivity variation falling by 10%. In any case, these two experiments illustrate a clear policy lesson: harmonization of policies may produce productivity gains and lower inter-provincial inequality.

### Autarky

To determine the value of the current level of economic integration and trade, we impose autarky on each region; that is, set  $\Delta_{ij} = \infty$  for all  $(i, j)$ . This evaluates the contribution of the current volume of trade to current productivity. Without trade, each region's own-share is unity,  $\pi_{ii} = 1$  for all  $i$ . The change in tradables productivity from its current level under this experiment is given by  $\pi_{ii}^{-1/\beta\theta}$ . On average, tradables productivity would decline by nearly 12.6% in autarky, with an aggregate impact of 3.8%. We also evaluate the impact of internal autarky, and leave each province able to trade only with an international partner or themselves. Setting  $\Delta_{ij} = \infty$  for all  $(i, j) \in \mathbb{C}^2$  causes productivity to fall by 1.2% in aggregate. This impact is much less than the case of full autarky, given the option to purchase from abroad varieties for which a province has low productivity. Figure 12 displays results for complete autarky and Figure 13 displays results for internal autarky.

### Comparison to International Trade Gains

For comparison, we estimate the gains from improved international trade. While we do not have an estimate of tariff-equivalent cost of crossing an international border, we illustrate a counterfactual where we reduce international trade costs by 20%. Specifically, we re-solve the model with bilateral geographic trade costs  $\tilde{\Delta}_{ij} = \Delta_{ij}/1.2$  for  $(i, j) \in \{\{i \in \mathbb{C}, j \notin \mathbb{C}\} \mid \{i \notin \mathbb{C}, j \in \mathbb{C}\}\}$ . Trade costs between all other pairs are unchanged. The results are displayed in Figure 14. Overall, national tradables productivity increases by more than 25%, resulting in an aggregate productivity increase of 7.6%. Ontario gains disproportionately from improved access to international markets. In this scenario, given disproportionate gains to Canada's more productive provinces, inter-provincial variation rises. An important result from this exercise is the relative similarities between the gains from external and internal trade liberalization. While a 20% reduction of trade costs between Canada and the world may or may not be feasible - we make no such claims here - it would certainly be difficult. Internal liberalization may be easier - politically at the very least - and therefore the gains more readily achievable.

## 7 Is Policy Reform Effective?

*WE WILL EXPAND THIS SECTION WITH MORE DETAILED ANALYSIS SOON.*

In an attempt to lower internal barriers, Canada's *Agreement on Internal Trade* (AIT) came into effect July 1, 1995. The stated goal of the AIT was to reduce and eliminate barriers to trade within Canada. It has been criticized as ineffective, as it is not legally binding and the dispute-resolution process does not impose monetary penalties for violations.<sup>16</sup> Using our flexible measure of trade costs over time between Canadian provinces, we can gauge the change in costs immediately following the AIT.

Figure 15 plots the average trade cost measure from the previous section for the years surrounding the AIT signing. For the peripheral Canadian provinces (the Maritime and Western provinces), there is a clear decline after the implementation of the AIT. Regressing  $\ln(\tau_{ijt})$  on an AIT dummy, and trading pair fixed effects, we find average bilateral trade costs fell by slightly over 10%.

## 8 Conclusion

The positive link between trade and productivity is well established. For a typical country, however, most exchanges between producers and consumers take place within national boundaries. The median country, for instance, allocates nearly three-quarters of consumer expenditure to domestic output. A large fraction of this is traded across sub-national boundaries. In Canada, the volume of goods and services traded across provincial boundaries is larger than between Canada and the world, with about 30% of a typical province's gross output exported to other Canadian provinces. In addition, poorer regions are disproportionately oriented towards internal rather than international trade. Any internal frictions that inhibit the free flow of goods and services across sub-national boundaries may lower national productivity and may influence regional inequality. In this paper, we estimate the magnitude, regional patterns, and productivity consequences of internal barriers to trade.

Methodological and data limitations have hindered past research into the effects of internal trade barriers. We use Canadian data on sub-national output and internal bilateral trade, data that is not readily available for other countries, and adapt recent techniques from the international trade literature. We find internal trade costs are substantial - on the order of 60%, on average. Large physical distances between trade partners in Canada explains only half of these costs, leaving a trade cost of 30% net of distance. Trade barriers for poor provinces are substantially larger than those for rich provinces, despite internal trade being relatively more important for the poorer regions.

Through counterfactual experiments, we find these large internal trade barriers can significantly lower aggregate productivity. Our framework adapts the recent new-trade model of Eaton and Kortum (2002) and Alvarez and Lucas

---

<sup>16</sup>As of May 2011, fifty-one disputes have been placed before the dispute resolution panel. Of these, 17 were resolved, 4 were denied, 4 were upheld, 11 are inactive, 5 were withdrawn and the remainder were deemed not subject to the AIT.

(2007). We depart from their formulation by explicitly incorporating a tax and transfer system, appropriate in the Canadian context, to generate persistent trade imbalances across provinces. Poor provinces have large trade deficits with the rest of Canada and neglecting this feature would impact our model's productivity estimates. Solving the model with alternative import cost scenarios demonstrates the significant gains from internal liberalization. Cutting internal barriers in half, for example, will raise national aggregate productivity by nearly 3% and eliminating the barriers completely will increase productivity by over 8%, closing the productivity gap between Canada and the United States to half its current size. Overall, we find improving the flow of goods and services across sub-national boundaries can significantly improve a country's productivity.

## References

- Adamopoulos, Tasso**, “Transportation Costs, Agricultural Productivity and Cross-Country Income Differences,” *International Economic Review*, 2011, 52 (2).
- Alvarez, Fernando and Robert Lucas**, “General equilibrium analysis of the Eaton-Kortum model of international trade,” *Journal of Monetary Economics*, 2007, 54 (6), 1726–1768.
- Amiti, Mary and Jozef Konings**, “Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia,” *American Economic Review*, 2007, 97 (5), 1611–1638.
- Anderson, James E. and Eric van Wincoop**, “Gravity with Gravitas: A Solution to the Border Puzzle,” *American Economic Review*, 2003, 93 (1), 170–192.
- and —, “Trade Costs,” *Journal of Economic Literature*, 2004, 42 (3), 691–751.
- Arkolakis, Costas, Arnaud Costinot, and Andres Rodriguez-Clare**, “New Trade Models, Same Old Gains?,” *NBER Working Paper, no. 15628*, 2009.
- Axtell, Robert**, “Zipf Distribution of U.S. Firm Sizes,” *Science*, 2001, 293 (5536), 1818–1820.
- Beaulieu, Eugene, James Gaisford, and Jim Higginson**, *Interprovincial trade barriers in Canada: How far have we come? Where should we go?*, Van Horne Institute for International Transportation and Regulatory Affairs, 2003.
- Bernard, Andrew B and J Bradford Jensen**, “Exporting and Productivity: The Importance of Reallocation,” Working Papers 01-02, Center for Economic Studies, U.S. Census Bureau 2001.
- Bernard, Andrew B., J. Bradford Jensen, and Peter K. Schott**, “Survival of the best fit: Exposure to low-wage countries and the (uneven) growth of U.S. manufacturing plants,” *Journal of International Economics*, 2006, 68 (1), 219–237.
- , **Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum**, “Plants and Productivity in International Trade,” *American Economic Review*, 2003, 93 (4), 1268–1290.
- Brandt, Loren, Trevor Tombe, and Xiaodong Zhu**, “Factor Market Distortions Across Time Space and Sectors in China,” 2010.
- Chaney, Thomas**, “Distorted Gravity: The Intensive and Extensive Margins of International Trade,” *American Economic Review*, 2008, 98 (4), 1707–21.
- Chen, Natalie**, “Intra-national versus international trade in the European Union: why do national borders matter?,” *Journal of International Economics*, 2004, 63 (1), 93–118.

- Corcos, Gregory, Massimo Del Gatto, Giordano Mion, and Gianmarco Ottaviano**, “Productivity and firm selection: quantifying the “new” gains from trade,” 2011.
- Donaldson, Dave**, “Railroads of the Raj: Estimating the Impact of Transportation Infrastructure,” 2010.
- Eaton, Jonathan and Samuel Kortum**, “Trade in capital goods,” *European Economic Review*, 2001, 45 (7), 1195–1235.
- and —, “Technology, Geography, and Trade,” *Econometrica*, 2002, 70 (5), 1741–1779.
- Frankel, Jeffrey A. and David Romer**, “Does Trade Cause Growth?,” *American Economic Review*, 1999, 89 (3), 379–399.
- Head, Keith and Thierry Mayer**, “Non-Europe: The magnitude and causes of market fragmentation in the EU,” *Review of World Economics (Weltwirtschaftliches Archiv)*, 2000, 136 (2), 284–314.
- and —, “Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade,” Working Papers 2002-01, CEPII research center 2002.
- Helliwell, John F. and Genevieve Verdier**, “Measuring internal trade distances: a new method applied to estimate provincial border effects in Canada,” *Canadian Journal of Economics*, 2001, 34 (4), 1024–1041.
- Henderson, Daniel J. and Daniel L. Millimet**, “Is gravity linear?,” *Journal of Applied Econometrics*, 2008, 23 (2), 137–172.
- Hillberry, Russell and David Hummels**, “Intranational Home Bias: Some Explanations,” *The Review of Economics and Statistics*, 2003, 85 (4), 1089–1092.
- Holz, Carsten A.**, “No Razor’s Edge: Reexamining Alwyn Young’s Evidence for Increasing Interprovincial Trade Barriers in China,” *The Review of Economics and Statistics*, 2009, 91 (3), 599–616.
- Hsieh, Chang-Tai and Peter J. Klenow**, “Misallocation and Manufacturing TFP in China and India,” *The Quarterly Journal of Economics*, 2009, 124 (4), 1403–1448.
- Hummels, David**, “Toward a Geography of Trade Costs,” *GTAP Working Papers, No. 1162*, 1999.
- Jacks, David S., Christopher M. Meissner, and Dennis Novy**, “Trade Costs, 1870-2000,” *American Economic Review*, 2008, 98 (2), 529–34.
- , —, and —, “Trade costs in the first wave of globalization,” *Explorations in Economic History*, 2010, 47 (2), 127–141.

- , —, and —, “Trade booms, trade busts, and trade costs,” *Journal of International Economics*, 2011, 83 (2), 185–201.
- Jones, Charles I.**, “The Shape of Production Functions and the Direction of Technical Change,” *The Quarterly Journal of Economics*, 2005, 120 (2), 517–549.
- Kortum, Samuel S.**, “Research, Patenting, and Technological Change,” *Econometrica*, 1997, 65 (6), 1389–1420.
- Melitz, Marc J.**, “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity,” *Econometrica*, 2003, 71 (6), 1695–1725.
- and **Giancarlo I. P. Ottaviano**, “Market Size, Trade, and Productivity,” *Review of Economic Studies*, 2008, 75 (1), 295–316.
- Nitsch, Volker**, “National borders and international trade: evidence from the European Union,” *Canadian Journal of Economics*, 2000, 33 (4), 1091–1105.
- Novy, Dennis**, “Gravity Redux : Measuring International Trade Costs with Panel Data,” Technical Report, University of Warwick, Department of Economics 2011.
- Pavcnik, Nina**, “Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants,” *Review of Economic Studies*, 2002, 69 (1), 245–76.
- Poncet, Sandra**, “A Fragmented China: Measure and Determinants of Chinese Domestic Market Disintegration,” *Review of International Economics*, 2005, 13 (3), 409–430.
- Redding, Stephen and Anthony J. Venables**, “Economic geography and international inequality,” *Journal of International Economics*, 2004, 62 (1), 53–82.
- Requena, Francisco and Carlos Llano**, “The border effects in Spain: an industry-level analysis,” *Empirica*, 2010, 37 (4), 455–476.
- Simonovska, Ina and Michael E. Waugh**, “The Elasticity of Trade: Estimates and Evidence,” Working Paper 16796, National Bureau of Economic Research 2011.
- Tombe, Trevor**, “The Missing Food Problem: How Low Agricultural Imports Contributes to International Income Differences,” *University of Toronto, Department of Economics, Working Paper 416*, 2010.
- Topalova, Petia and Amit Khandelwal**, “Trade Liberalization and Firm Productivity: The Case of India,” *The Review of Economics and Statistics*, 2011, 93 (3), 995–1009.
- Trefler, Daniel**, “The Long and Short of the Canada-U. S. Free Trade Agreement,” *American Economic Review*, 2004, 94 (4), 870–895.



**Trela, Irene and John Whalley**, “Regional Aspects of Confederation,” in “Research Papers for the Royal Commission on the Economic Union and Development Prospects for Canada,” Vol. 68, University of Toronto Press, 1986.

**Waugh, Michael E.**, “International Trade and Income Differences,” *American Economic Review*, 2010, 100 (5).

**Whalley, John**, “The Impact of Federal Policies on Interprovincial Activity,” in M. Trebilcock, T.J. Courchene, and J. Whalley, eds., *Federalism and the Economic Union*, University of Toronto Press, 1983, pp. 201–242.

**Wolf, Holger C.**, “Intranational Home Bias In Trade,” *The Review of Economics and Statistics*, 2000, 82 (4), 555–563.

**Yilmazkuday, Hakan**, “Understanding interstate trade patterns,” *Journal of International Economics*, forthcoming, 2011.

**Young, Alwyn**, “The Razor’s Edge: Distortions And Incremental Reform In The People’S Republic Of China,” *The Quarterly Journal of Economics*, 2000, 115 (4), 1091–1135.

## Tables and Figures

Table 3: Bilateral Trade Costs

	AB	BC	MB	NB	NL	NS	ON	PE	QC	SK
AB	0									
BC	47	0								
MB	58	76	0							
NB	99	113	110	0						
NL	110	128	129	53	0					
NS	99	100	108	51	60	0				
ON	49	57	58	69	78	65	0			
PE	132	141	141	58	89	69	88	0		
QC	67	70	74	58	70	73	40	96	0	
SK	49	76	56	115	145	118	62	155	86	0

Bilateral trade costs for 2005 estimated from Equation 1. It represents the average bilateral trade costs relative to domestic/internal trade costs. Rounded to nearest integer.

Table 4: Trade Flow Regression Results

Variable	Dep. Var.: $\ln\left(\frac{\pi_{ijt}}{\pi_{iit}}\right)$	
	(1)	(2)
Log(Distance Between Capitals)	-1.174*** [-40.67]	
Log(Average Population Distances)		-1.183*** [-44.45]
D=1, if Share Border	0.152*** [2.99]	0.0834* [1.73]
Exporter FEs	Yes	Yes
Importer FEs	Yes	Yes
Observations	1210	1210
$R^2$	0.991	0.992

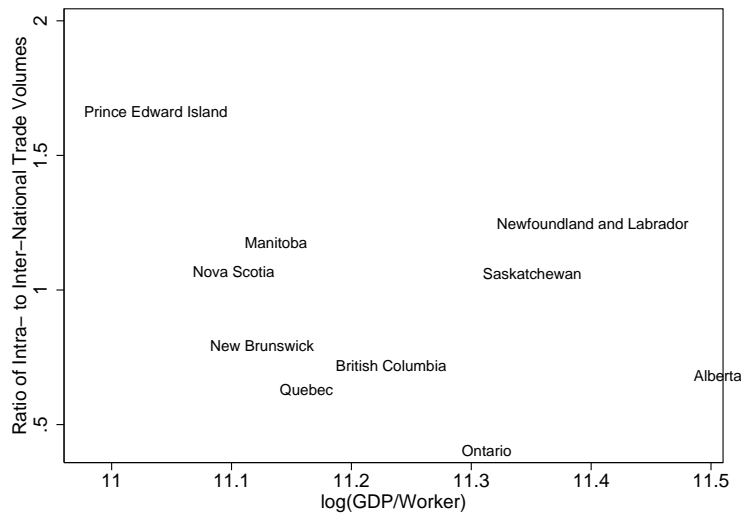
Reports estimates from the gravity regression of trade between Canadian provinces and the United States between 1997 and 2007, using specification from Equation 7. Column (1) uses kilometers between capital cities. Column (2) uses population-weighted average distance between all cities.

Table 5: Trade Costs and Fixed Effects Estimates

Province	Exporter	Importer	Import	Barrier's Price	Standard Errors		
	FE	FE	Barrier	Impact	$\hat{\eta}_i$	$\hat{\iota}_i$	$-(\hat{\eta}_i + \hat{\iota}_i)$
	$\hat{\eta}_i$	$\hat{\iota}_i$	$-(\hat{\eta}_i + \hat{\iota}_i)$	$100 \left( e^{-\frac{(\hat{\eta}_i + \hat{\iota}_i)}{\theta}} - 1 \right)$			
Alberta	1.55	-0.04	-1.52	-17	0.227	0.320	0.321
British Columbia	1.19	-0.06	-1.13	-13	0.227	0.322	0.326
Manitoba	-0.22	0.03	0.19	2	0.227	0.316	0.313
New Brunswick	-0.79	0.27	0.52	7	0.228	0.309	0.300
Newfoundland and Labrador	-1.16	0.63	0.53	7	0.229	0.312	0.307
Nova Scotia	-0.71	0.05	0.66	9	0.229	0.305	0.294
Ontario	2.32	-0.45	-1.88	-21	0.228	0.311	0.304
Prince Edward Island	-3.1	0.13	2.97	45	0.230	0.302	0.289
Quebec	1.26	-0.49	-0.77	-9	0.227	0.312	0.305
Saskatchewan	-0.36	-0.07	0.42	5	0.227	0.317	0.315

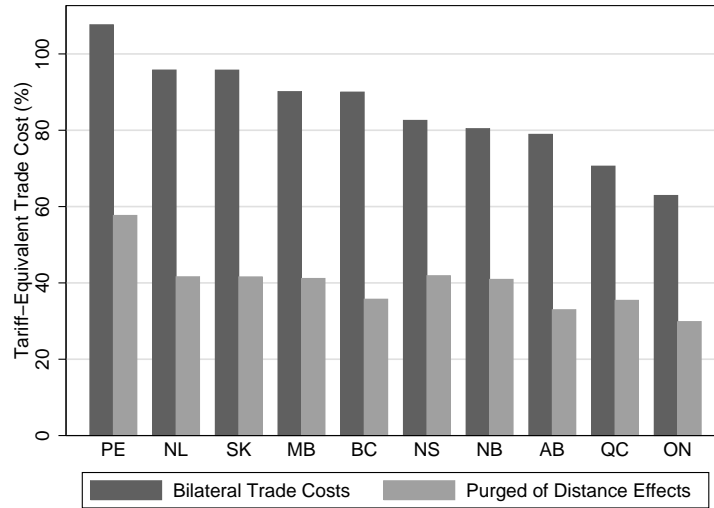
Reports estimates from the regression specification in Equation 7. Fixed effects are normalized such that  $\sum_{i \in C} \hat{\eta}_i = \sum_{i \in C} \hat{\iota}_i = 0$ .

Figure 1: Ratio of Internal to External Trade Volumes, Year 2005



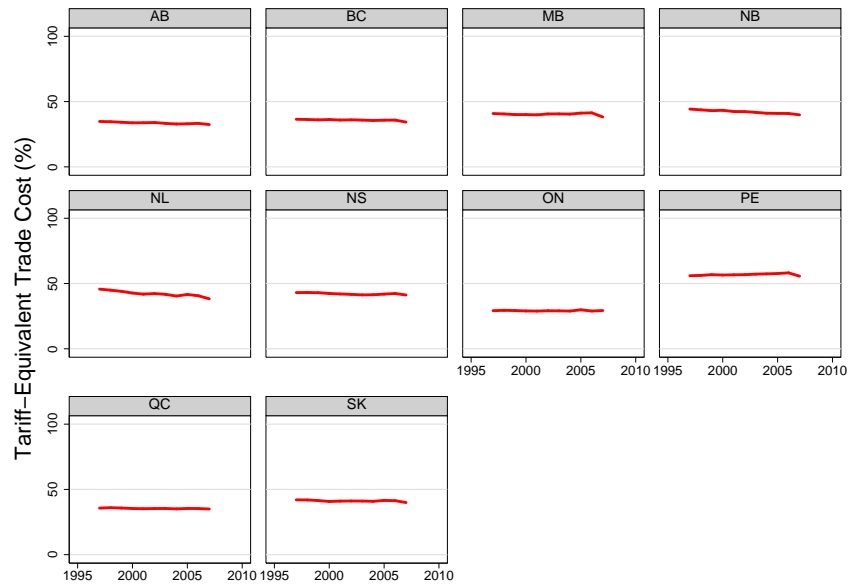
Displays the ratio of the volume of imports and exports within Canada, by province, to the volume internationally. Internal trade volumes relative to international trade volumes are decreasing in provincial aggregate productivity and income.

Figure 2: Trade-Weighted Costs, by Province, for 2005



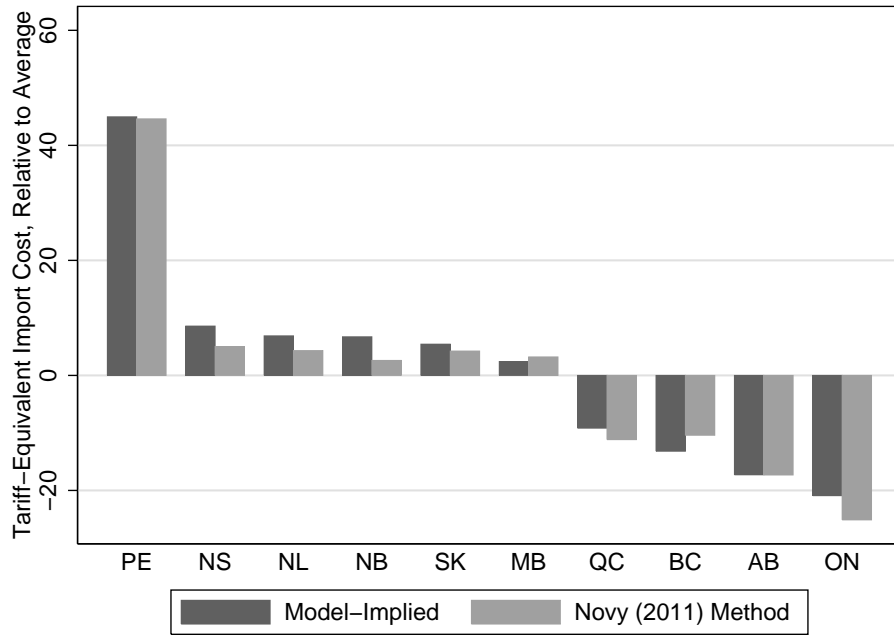
Trade-weighted trade costs by province for 2005 estimated from Equation 1. It represents the average bilateral trade costs relative to domestic/internal trade costs. Details of removing distance effects are in the text.

Figure 3: Average Trade Costs, Flexible Measure, Purged of Distance Effects



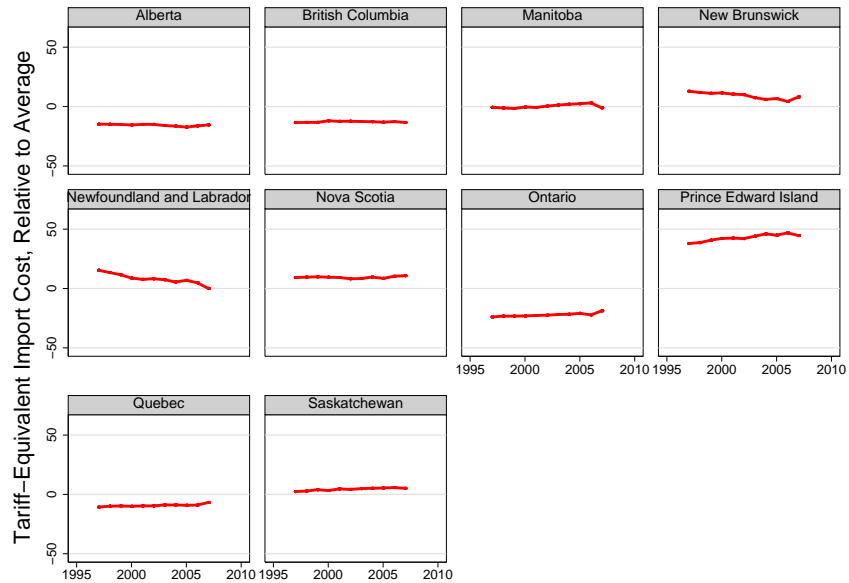
Average trade costs by province over time, estimated from Equation 1. It represents the average bilateral trade costs over and above within-province distribution costs.

Figure 4: Internal Import Barriers, by Province, for Both Methods



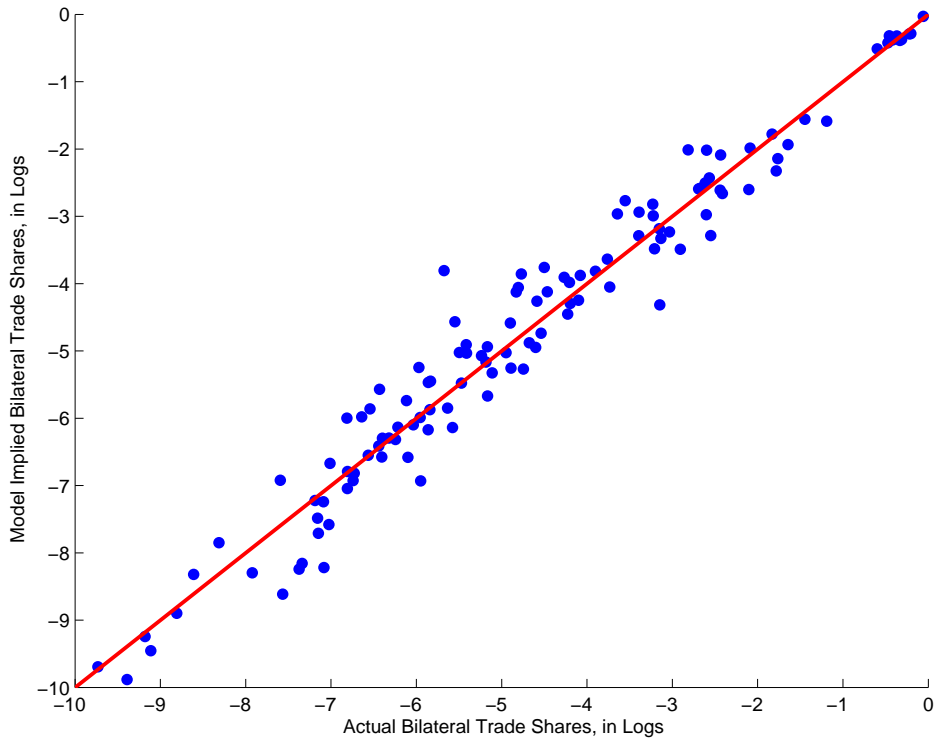
Compares flexible method to the province-specific import cost estimates from the model. Flexible costs are displayed as simple average across export partners, for each importing province, purged of bilateral distance effects, in year 2005. Measures are normalized relative to the average province.

Figure 5: Province-Specific Internal Import Barriers, Model Based Measure



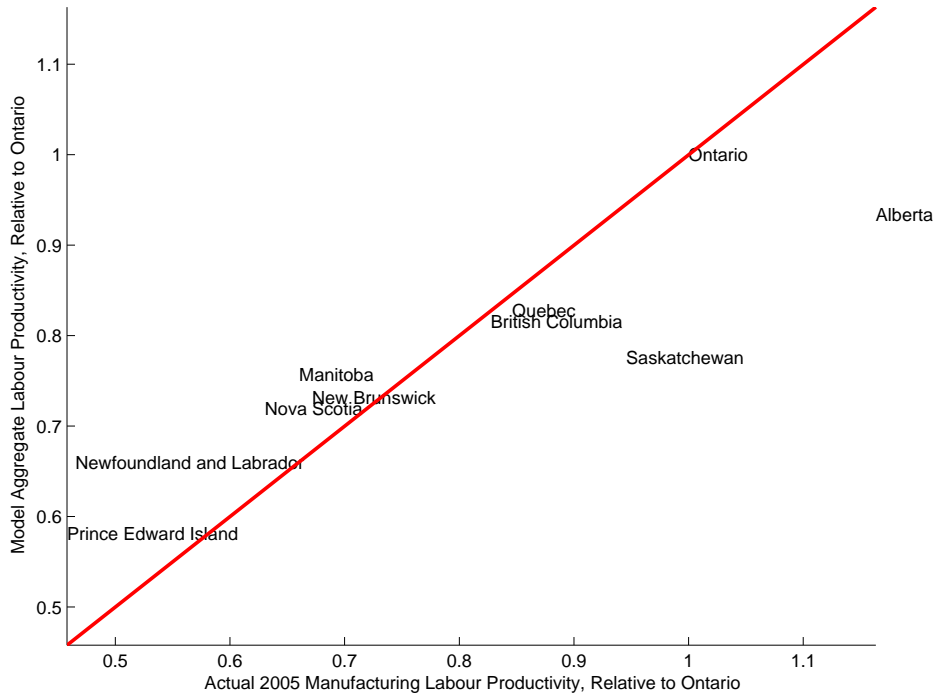
Model-implied import costs, by province, in tariff equivalent terms over time. Reflects all costs to import, including within-province distribution costs.

Figure 6: Comparing Model Trade Shares to Data



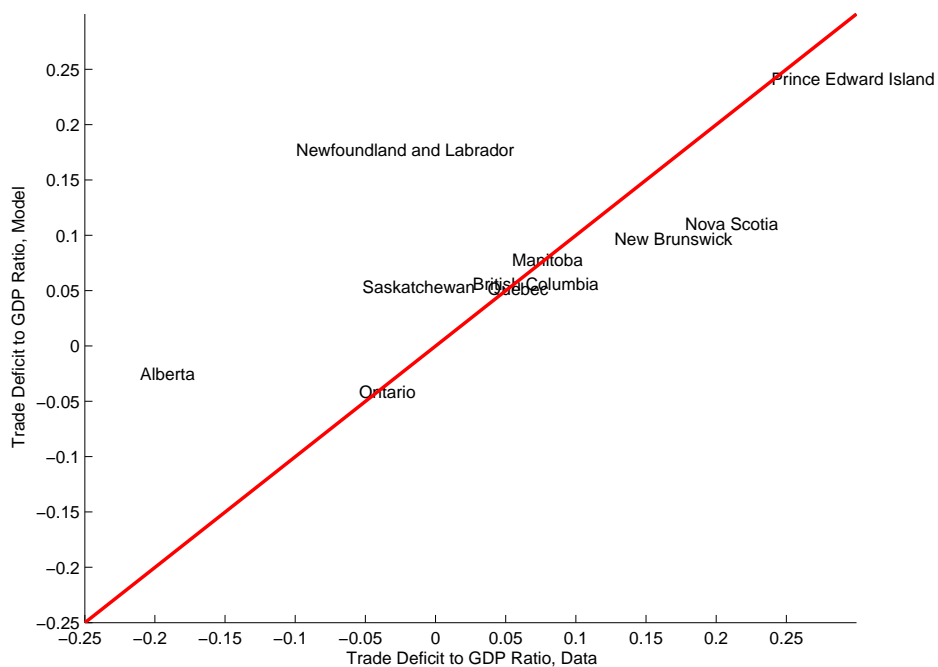
Compares bilateral trade shares between the model and data. Each dot is a pair of regions.

Figure 7: Comparing Model Labour Productivity to Data



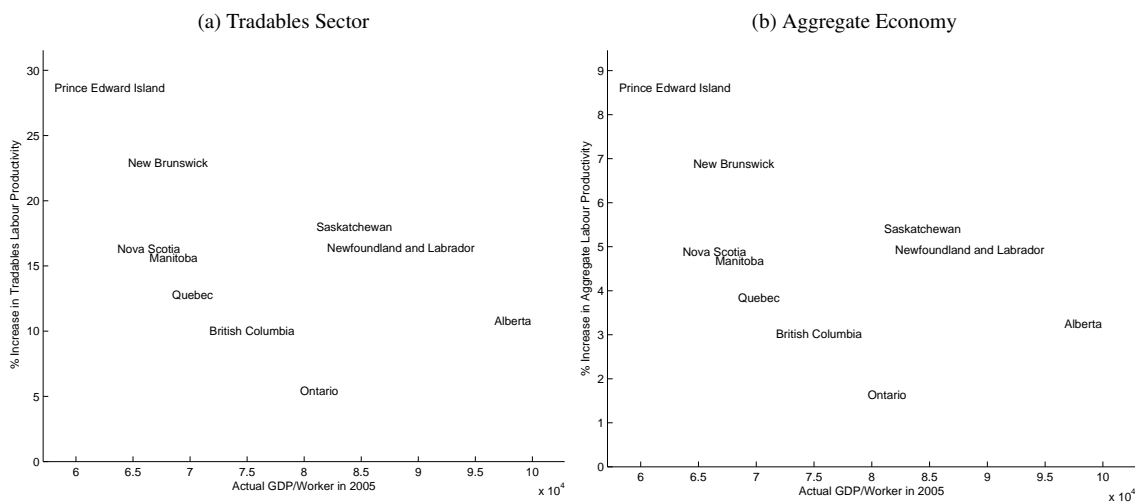
Labour productivity implied by the model is compared to data on provincial manufacturing labour productivity in 2005.

Figure 8: Comparing Model Trade Deficits to Data



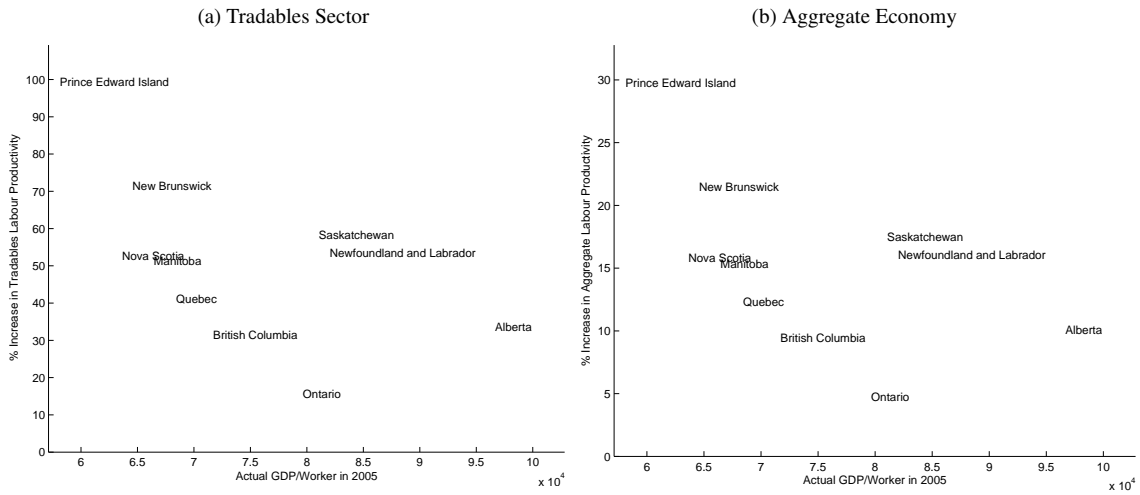
Model-implied trade deficits, by province, induced by redistributive taxation. The outliers - Alberta and Newfoundland and Labrador - are due to extensive oil exports not captured by the model.

Figure 9: Counterfactual Increase in Productivity from Reducing Internal Import Barriers by 50%



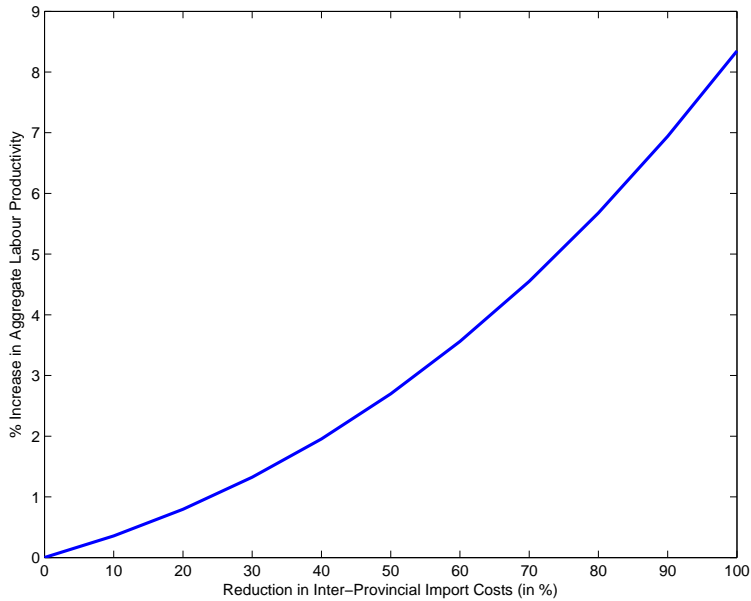
Displays counterfactual change in provincial labour productivity from a reduction in the province-specific import barriers (with respect to exporters within Canada, not abroad) by 50%. The plots illustrate poorer provinces receive the greatest increase in productivity.

Figure 10: Counterfactual Increase in Productivity from Eliminating Internal Import Barriers



Displays counterfactual change in provincial labour productivity from a reduction in the province-specific import barriers (with respect to exporters within Canada, not abroad) by 100%. The plots illustrate poorer provinces receive the greatest increase in productivity.

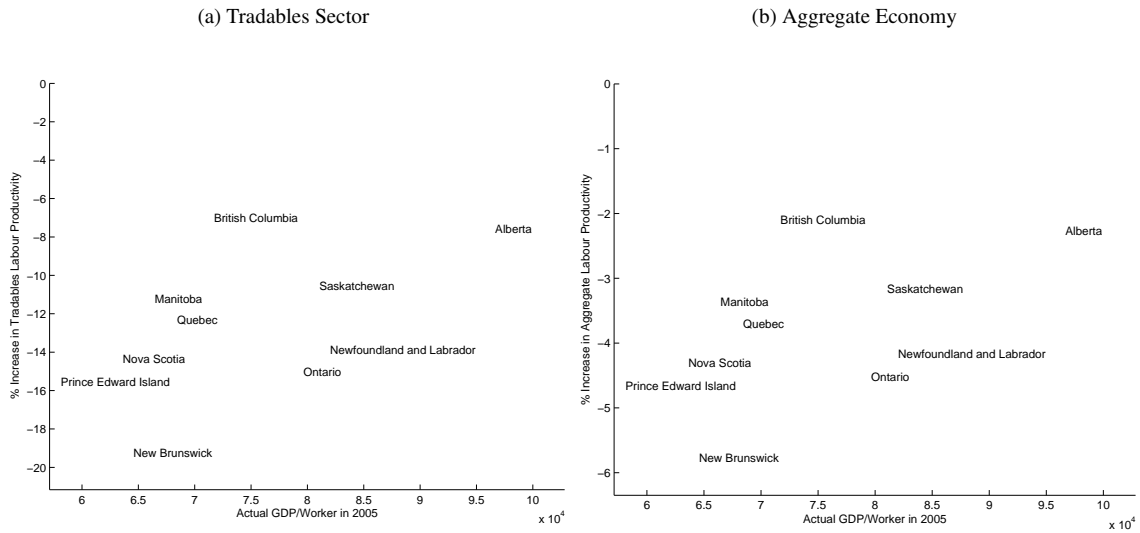
Figure 11: Reducing Internal Import Costs Increases Aggregate Labour Productivity



Displays counterfactual increases in aggregate Canadian productivity for various tariff reductions. The x-axis measure the percent reduction in import costs. The y-axis measures gains in Canada's aggregate labour productivity, in percentage point increases.

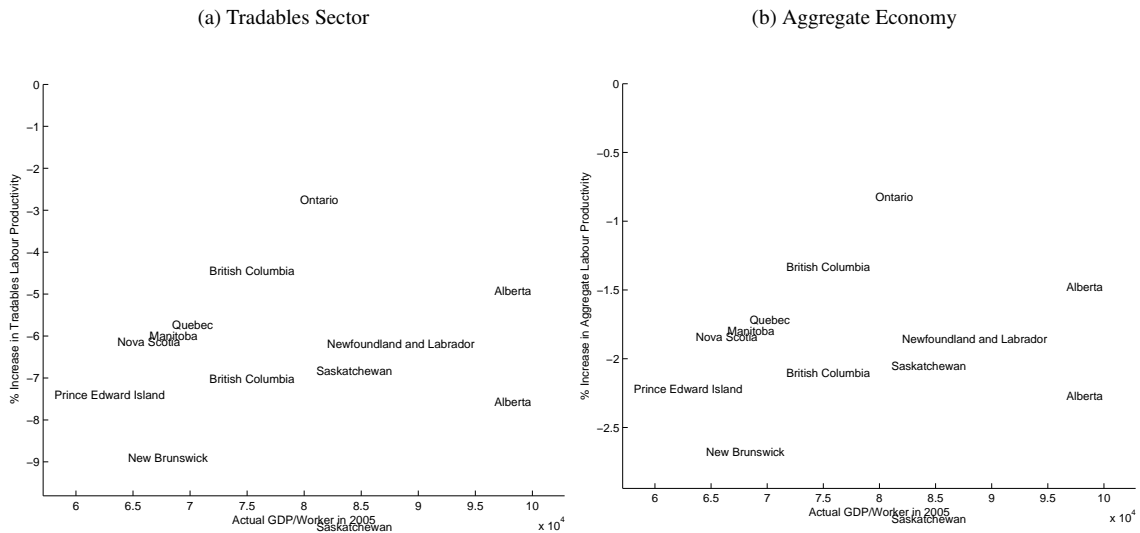


Figure 12: Counterfactual Decrease in Labour Productivity from Complete Autarky



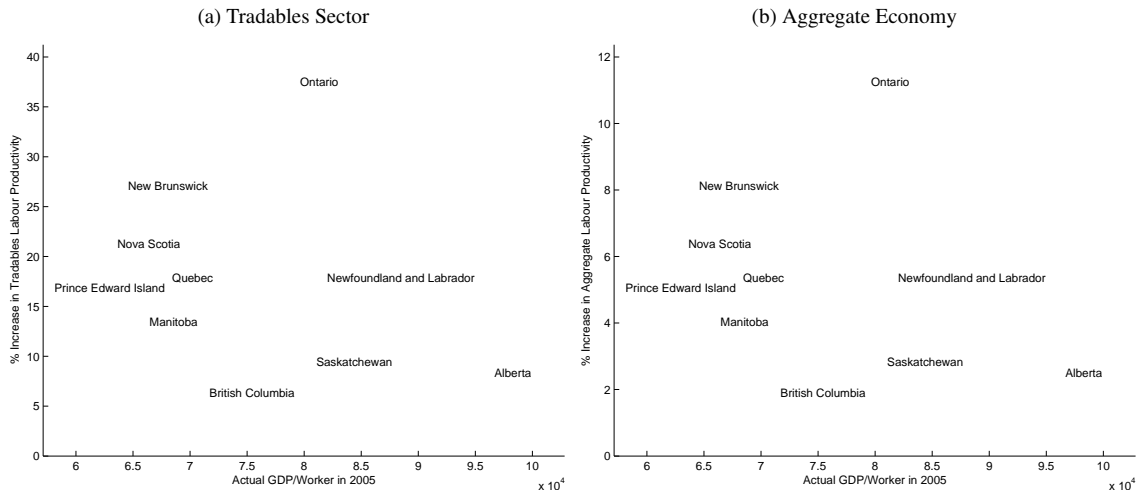
Displays impact on provincial labour productivity from complete autarky - no trade.

Figure 13: Counterfactual Decrease in Labour Productivity from Internal Autarky



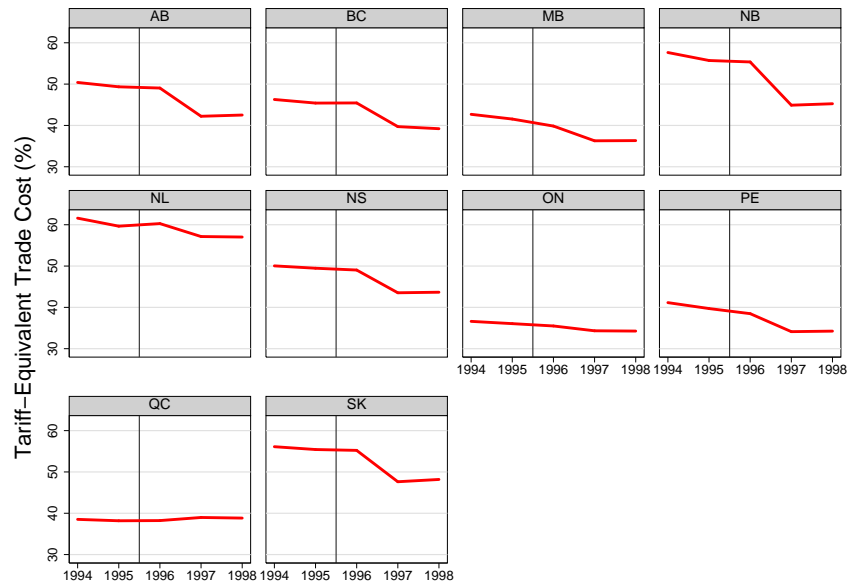
Displays impact on provincial labour productivity from internal autarky - cannot trade with other Canadian provinces but can trade internationally. This reflects the value of Canada's internal economic integration.

Figure 14: Increase in Labour Productivity from 20% Lower International Trade Cost



Displays increase in labour productivity from 10% lower trade costs between an international trade partner and Canadian provinces.

Figure 15: Average Trade Costs, Flexible Measure, Earlier Dates



Average trade costs by province over time, estimated from Equation 1, purged of distance-effects (details in text). It represents the average bilateral trade costs over and above within-province distribution and distance-related costs. Vertical line is mid-1995, the implementation date of the Agreement on Internal Trade.