Internal Trade, Productivity, and Interconnected Industries: A Quantitative Analysis

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Abstract

Does trade within a country affect welfare and productivity? What are the magnitude and consequences of costs to such trade? To answer these questions, we exploit unique Canadian data to measure internal trade costs in a variety of ways – they are large, and vary across sectors and provinces. To quantify their consequences for welfare and productivity, we use a recent multi-sector trade model featuring rich input-output relationships. We find inter-provincial trade is an important contributor to Canada's GDP and welfare, though there are significant costs to such trade. Reducing inter-provincial trade costs by 10% yields aggregate gains of 0.9%; eliminating our preferred estimates of costs, gains average between 3-7% – equivalent to real GDP gains between $50-$130 billion. Finally, as policy reforms are often sector-specific, we liberalize sectors one at a time and find gains are largest in highly interconnected industries.

JEL Classification: F1, F4, R1

Keywords: Internal trade; gains from trade; input-output linkages

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1 Introduction

Is it more costly to trade across a provincial boundary than it is to trade within a province? If so, what effect do such costs have on aggregate welfare (real GDP) or industry productivity? Unlike barriers to international trade, the effect of barriers to trade *within countries* is only beginning to receive significant attention – largely due to recent theoretical advances and the availability of high-quality data on inter-provincial trade (hereafter, internal trade). In this paper, we quantify the magnitude and consequences of internal trade costs across a variety of sectors and identify the most valuable sectors for policy makers to reform. This is relevant, as efforts to reduce internal trade costs are often sector-specific – especially in Canada. Our analysis exploits uniquely detailed data from Canada on internal trade and a recent multi-sector trade model featuring rich input-output relationships (Caliendo and Parro, 2015). We find internal trade costs are large, vary across sectors and provinces, and reduce productivity and welfare. They also interact with input-output relationships – liberalizing highly interconnected industries yields the largest gains.

What are internal trade costs? Of course, explicit tariffs do not exist, but a wide variety of regulatory restrictions on the movement of goods and services can have substantial effects on trade. While Beaulieu et al. (2003) give an excellent summary, let us provide some examples. Provincial licensing requirements for stock brokers, accountants, lawyers, and other professions, prevent customers in one province from hiring providers registered in another. Different regulations between provinces, for long-haul freight transportation or product safety standards, for example, also increase costs of trade between provinces. Biased government procurement policies, where governments and agencies give preferences to within-province suppliers, are also trade costs. These measures, and more, suggest there is scope for internal liberalization – a fact recognized by Canadian policy makers and politicians (Ivison, 2014).

We use a variety of techniques to estimate internal trade costs, starting with the Head-Ries index of trade restrictiveness (Head and Ries, 2001; Novy, 2013). We leave the details behind this measure to the next section, but a brief intuitive description is useful here. The index infers trade costs, which are not observable, from provincial production and trade flows, which are. Essentially, trade costs generate systematic tendencies among provinces to allocate more spending to their own producers, rather than producers in other provinces. The index, however, infers trade costs *relative* to costs of trading *within provinces* (say, between Calgary and Edmonton). In addition, it does not isolate policy-relevant costs from other factors such as distance. To address these limitations, we explore two other measures. First, trade costs may be higher in one direction of flow (say, from Alberta to Ontario) than in the other (Ontario to Alberta). This *asymmetry* in trade costs is an important feature of both international trade (Waugh, 2010) and internal trade (Tombe and Winter, 2014). They likely better reflect policy-relevant costs and are not valued relative to within-province costs. We identify these asymmetries as in the literature and find they are large, adding nearly 8% to average internal trade costs. Our second measure supposes the primary driver of trade costs unrelated to policy is physical distance. As the Head-Ries index describes average between-province trade costs relative to within-province trade costs, we essentially regress the index on a measure of distance between provinces relative to within-province distances (between cities). The residuals from this regression may be informative of policy-relevant trade costs. On average, these non-distance costs add 15% to average internal trade costs. With both measures, we find poor regions tend to face the highest internal trade costs.

What are the consequences of these internal trade costs on productivity and welfare in Canada? To answer this question, we use a recent model featuring multiple interconnected industries developed by Caliendo and Parro (2015). When solved using the "Exact-Hat Algebra" of Dekle et al. (2007), the model is a highly tractable quantitative tool for evaluating trade policy. While we postpone a more detailed discussion to section 3, it is straightforward to see why interconnections between multiple industries matters. With input-output links, changes to one sector affect many others since the output of one is an input for another. Gains from trade are therefore amplified by each sector's "influence" on the aggregate economy. A summary measure of this influence is found in many literatures: the vector of TFP Multipliers in Jones (2013), the Influence Vector in Acemoglu et al. (2012) and Carvalho and Gabaix (2013), or (more loosely) the vector of Sales/GDP ratios in Hulten (1978). We derive an analogous measure in proposition 2 and demonstrate trade and trade costs matter more in more "influential" sectors. Sectors with large input-output multipliers tend to have (1) large internal trade flows and (2) large gains from trade liberalization.

With the model, we perform a variety of quantitative experiments. We first ask: Who gains from trade in Canada? This is a common experiment in the international trade literature and involves comparing initial welfare to the counterfactual level of welfare when trade is prohibited. We find aggregate welfare is 18.3% higher than in autarky. Compared to the case of no inter-provincial trade, but allowing for international trade, aggregate welfare is 4.4% higher. For internal trade costs, reducing them by 10% increases aggregate welfare by roughly 0.9% (equivalent to a real GDP increase of $17 billion). Eliminating trade cost asymmetries, aggregate gains are over 3%; removing trade costs unrelated to distance, gains are nearly 7%. These estimates suggest reducing internal trade barriers could add $50-$130 billion to Canada's GDP. If inter-provincial trade costs were completely eliminated, an implausible but illustrative experiment, aggregate gains for Canada exceed 50%. Moreover, we consistently find poor regions gain more from liberalization than rich regions.

In addition to aggregate outcomes, we explore a variety of industry-specific results, as policy reforms are often piecemeal. A 10% reduction in internal trade costs for the agriculture and mining sector increases aggregate welfare by 0.1%. Other important sectors include food, textiles, wholesale and retail trade, and finance – all with gains around 0.1% for a 10% reduction of their trade costs. The gains from sector-specific liberalizations are closely related to input-output links – highly interconnected industries, as measured by a sector's "influence", have the largest gains from trade liberalization. We already know from Caliendo and Parro (2015) and Costinot and Rodriguez-Clare (2014) that inter-sectoral linkages are key for aggregate gains from trade – typically more than doubling gains from trade. Our sector-specific liberalizations build on that result to identify key sectors for reform.

Our work fits within a recent and growing literature, measuring the magnitude and effect of internal barriers to trade. Typically, work in this area exploits gravity-based empirical approaches to measure internal trade costs for a variety of countries, from the United States (Wolf, 2000; Hillberry and Hummels, 2003; Yilmazkuday, 2012) and the European Union (Nitsch, 2000; Chen, 2004) to China (Poncet, 2005). For Canada, Anderson and Yotov (2010) investigate the nature and consequences of internal trade costs, though their main focus is on who pays for trade costs (its incidence). They also simulate potential gains from trade cost reductions and find poor regions stand to gain more than rich – a result we confirm. Finally, the two most closely related papers in this literature are Agnosteva, Anderson and Yotov (2014) and Tombe and Winter (2014). Tombe and Winter (2014) take an aggregate approach to measure internal trade costs in Canada, the United States, and China and focus on the interaction of trade costs with federal tax and transfer systems. Agnosteva, Anderson and Yotov (2014) develop a novel approach to estimate policy-relevant internal trade costs, even by sector and within provinces, although they do not quantify the effect of trade or trade costs on productivity and welfare. Our work complements theirs.

Overall, our purpose is neither to provide theoretical nor empirical innovations; instead, we use high-quality and detailed data with frontier methods from the international trade literature (Head and Ries, 2001; Waugh, 2010; Caliendo and Parro, 2015) to increase understanding of the magnitude and consequences of internal trade costs at the sector level. This is an active and important policy area, especially for Canada.

2 Canadian Internal Trade and Its Costs

This section examines in detail the nature and composition of Canada's internal trade, especially how it varies by province and sector. The data for our analysis are uniquely detailed. Statistics Canada provides high quality province and commodity-level trade data, both within Canada and with the rest of the world (captured as a single entity).[1] We aggregate commodities into industries based on OECD-STAN data, combining sectors where necessary to ensure positive production in each province and sector. Details are in Appendix A.

2.1 Export Orientation of Provinces and Industries

Table 1a displays each province's share of output exported. Overall, just over one-quarter of production is exported. Province vary: Newfoundland and Labrador, Saskatchewan, and New Brunswick all export more than a third of their output while Nova Scotia and British Columbia export less than a quarter of theirs. Internal trade is almost as important as international trade. Comparing columns two and three of Table 1a, we find roughly 60% of all goods exported from a

[1] Statistics Canada infers inter-provincial trade from a variety of sources such that provincial supply and demand constraints (from Provincial IO Tables) are respected. Goods trade is largely based on shipment information from the Annual Survey of Manufacturers and the Wholesale Origin and Destination Survey. Services trade, however, faces greater difficulties; for example, there is no source of bilateral trade in financial services and Statistics Canada imputes trade with a number of ad-hoc approaches. For further detail, see Généreux and Langen (2002).

Table 1: Share of Output Exported, by Province

(a) By Province

Province	Total Exports	*Inter*national Exports	*Intra*national Exports
Newfoundland	36%	20%	16%
New Brunswick	34%	19%	15%
Saskatchewan	34%	22%	12%
Alberta	28%	16%	12%
Manitoba	28%	13%	15%
Ontario	25%	16%	9%
Prince Edward Island	25%	11%	14%
Quebec	24%	13%	11%
Nova Scotia	22%	10%	12%
British Columbia	21%	11%	10%
Average	26%	15%	11%

(b) By Sector

Sector	ISIC (Rev3) Codes	Total Exports	*Inter*national Exports	*Intra*national Exports
Equipment, Vehicles	29-35	77%	66%	11%
Paper	21-22	64%	45%	19%
Metals	26-28	60%	45%	15%
Agriculture, Mining	01-14	59%	41%	18%
Food, Textiles	15-19	58%	23%	35%
Chemicals, Rubber	23-25	55%	35%	21%
Manufacturing, n.e.c.	36-37	53%	33%	20%
Wood	20	53%	32%	21%
Transport	60-63	31%	14%	17%
Other Business Services	73-74	26%	11%	14%
Hotels and Restaurants	55	24%	11%	13%
Communication	64	24%	7%	16%
Wholesale and Retail	50-52	23%	10%	13%
Finance	65-67	20%	4%	16%
Software	72	18%	8%	10%
Other Services	90-93	9%	2%	7%
Utilities	40-41	5%	4%	1%
Real Estate	70-71	4%	1%	2%
Education	80	3%	2%	1%
Health and Social	85	1%	0%	1%
Public Admin.	75	0%	0%	0%
Construction	45	0%	0%	0%

Displays shares of gross output exported inter-provincially or internationally. Trade and output data from CANSIM 386-0003. Overall average is output-weighted.

province are sent abroad and 40% are sent to other provinces, though there are differences between provinces. At the high end, 22% of Saskatchewan's output is exported abroad compared to only 10% of Nova Scotia's. The share of output exported within Canada varies less across provinces, ranging from 16% for Newfoundland and Labrador to 9% for Ontario. For some regions, internal

Table 2: Revealed Comparative Advantage, by Province and Industry

Commodity	Province AB	BC	MB	NB	NL	NS	ON	PE	QC	SK
Agriculture, Mining	2.41	0.86	1.20	0.50	5.76	0.62	0.19	0.93	0.37	2.56
Chemicals, Rubber	1.47	0.29	0.52	3.10	0.02	1.77	0.72	0.31	1.32	0.68
Communication	0.70	0.83	0.95	0.40	0.46	1.16	1.28	0.56	1.12	0.54
Equipment, Vehicles	0.41	0.59	1.64	0.32	0.07	0.70	1.19	0.35	1.49	1.27
Finance	0.28	0.64	0.82	0.38	0.25	0.64	1.84	0.72	0.79	0.38
Food, Textiles	0.77	0.95	1.34	0.86	0.12	1.08	0.93	2.30	1.37	1.05
Metals	0.38	0.67	0.84	0.50	0.00	0.42	1.29	0.31	1.64	0.58
Other Business Services	0.94	1.09	0.71	1.40	0.41	0.78	1.22	1.19	0.84	0.42
Transport	0.86	1.84	1.50	0.80	0.63	1.21	0.85	1.06	0.79	1.47
Wholesale and Retail	0.79	1.32	0.82	0.47	0.15	0.72	1.23	0.53	0.92	0.82

Revealed comparative advantage index is a measure of each sector's share of a province's total exports, relative to the (total-export weighted) average share across all provinces. See text for details.

trade is even more important than external. Manitoba, for example, exports 13% of its output abroad and 15% to other provinces.

We report the same export shares for major industries in Table 1b. Equipment and vehicles, paper, metals, agricultural and mining are among the most export oriented sectors. The importance of internal trade is largest for food and beverages, with over one-third of output exported to other provinces but less than one-quarter exported abroad. Internal trade is also much more important than international trade for service sectors, such as finance, communication, transport and storage, wholesale and retail trade. Of course, there are also a few industries that have very little trade, internally or internationally, such as utilities, real estate, education, or health.

Do provinces specialize in different industries? A simple metric to summarize specialization patterns across regions is Balassa (1965)'s Revealed Comparative Advantage (RCA) index. The index compares the distribution of a region's exports across industries to an average. More precisely, $RCA_n^j = s_n^j / \bar{s}^j$, where s_n^j is the share of sector j in region n's total exports and $\bar{s}^j$ is the export-weighted average share across all exporters. For the ten most heavily traded industries, we report the RCA measure for each province in Table 2. Values above one indicate a revealed comparative advantage. Alberta, for example, has an RCA above one for agriculture, mining and chemical, rubber (which includes refining) – not surprising given its large natural and oil and gas endowments. Manitoba also has an RCA above one in agriculture, mining, and equipment and vehicles (it is home to large bus and tractor manufacturers). The broad patterns of the table are that western provinces (and Newfoundland) have high RCA in resource sectors while central Canada has high RCA in manufacturing, communication, and finance.

2.2 A Simple (but Powerful) Measure of Trade Costs: The Head-Ries Index

Having described trade among provinces and industries, we now turn to a measure of bilateral trade shares that will prove useful for inferring trade costs. For total imports by region n from region i (denoted X_{ni}), define $\pi_{ni} = X_{ni} / \sum_{i=1}^{N} X_{ni} \equiv X_{ni} / X_n$ as the share of spending region n

Table 3: Home-Shares and Average Import Shares, by Industry

Commodity	Province									
	AB	BC	MB	NB	NL	NS	ON	PE	QC	SK
(a) Share of Expenditures on Own (Within-Province) Producers										
Agriculture, Mining	0.82	0.63	0.60	0.10	0.35	0.36	0.38	0.77	0.39	0.60
Chemicals, Rubber	0.54	0.21	0.08	0.45	0.06	0.33	0.43	0.10	0.42	0.15
Communication	0.69	0.70	0.64	0.60	0.62	0.61	0.80	0.59	0.74	0.59
Equipment, Vehicles	0.12	0.06	0.11	0.00	0.00	0.10	0.24	0.04	0.12	0.07
Finance	0.66	0.75	0.72	0.68	0.60	0.69	0.88	0.71	0.78	0.59
Food, Textiles	0.21	0.22	0.17	0.17	0.23	0.22	0.44	0.15	0.40	0.12
Metals	0.40	0.36	0.25	0.26	0.08	0.23	0.41	0.22	0.47	0.16
Other Business Services	0.78	0.75	0.54	0.60	0.53	0.65	0.83	0.65	0.78	0.50
Transport	0.71	0.75	0.69	0.67	0.57	0.57	0.72	0.38	0.73	0.61
Wholesale and Retail	0.85	0.82	0.72	0.66	0.65	0.70	0.92	0.58	0.85	0.74
(b) Share of Expenditures from Other Provinces on Each Province's Producers										
Agriculture, Mining	0.11	0.01	0.01	0.01	0.05	0.01	0.03	0.00	0.01	0.02
Chemicals, Rubber	0.10	0.01	0.01	0.09	0.00	0.04	0.08	0.00	0.06	0.01
Communication	0.03	0.02	0.01	0.00	0.00	0.01	0.15	0.00	0.06	0.00
Equipment, Vehicles	0.01	0.01	0.01	0.00	0.00	0.00	0.07	0.00	0.04	0.01
Finance	0.01	0.01	0.01	0.00	0.00	0.00	0.21	0.00	0.03	0.00
Food, Textiles	0.06	0.03	0.02	0.02	0.00	0.03	0.16	0.01	0.10	0.02
Metals	0.03	0.02	0.01	0.01	0.00	0.01	0.15	0.00	0.07	0.00
Other Business Services	0.06	0.02	0.01	0.02	0.01	0.01	0.13	0.00	0.03	0.00
Transport	0.04	0.04	0.01	0.02	0.01	0.02	0.10	0.00	0.05	0.01
Wholesale and Retail	0.04	0.02	0.01	0.01	0.00	0.02	0.12	0.00	0.05	0.01

Displays shares of gross output exported inter-provincially or internationally. Trade and output data from CANSIM 386-0003. All shares are strictly positive – values are rounded to two decimal places.

allocates to goods from region i, where region n's total spending is X_n. This expression holds equally well when $n = i$, in which case this represents the home-share of spending $\pi_{nn} = 1 - \sum_{i \neq n} \pi_{ni}$. The data provides both bilateral trade X_{ni} and total spending X_n.

These shares are informative of trade costs. If trade is completely costless and consumers have identical preferences, then the share of a province's expenditure allocated to goods from a given source region will be the same for all provinces. That is, if Ontario is the most productive (lowest cost) source for products accounting for 25% of spending, then consumers *everywhere* will allocate 25% of their spending to goods from Ontario. In the data, shares are far from equal. Table 3 reports the home-share and the mean share of expenditure from other provinces for the top ten traded industries.[2] Panel (a) indicates that home-shares are often very large; though there are exceptions – equipment and vehicles, for example. Compare these to the average expenditure shares from other provinces in panel (b). For example, 82% of Alberta's total expenditure on agricultural and mining goods (including oil and gas extraction) is allocated to producers within Alberta. The typical share of total expenditures by other provinces allocated to those same Alberta producers is only 11%. It is quite clear from comparing panel (a) to (b) that home-shares are systematically larger than expenditures shares by other provinces.

To infer unobservable trade costs from these expenditure shares, Head and Ries (2001) and

[2] The mean share of other provinces' spending is $\frac{1}{N-1} \sum_{n \neq i} \omega_{ni} \pi_{ni}$, where ω_{ni} are expenditure weights.

Novy (2013) demonstrate a broad class of trade models imply the average trade cost in industry j between two regions n and i is

$$\bar{\tau}^j_{ni} \equiv \sqrt{\frac{\tau^j_{ni}}{\tau^j_{nn}}\frac{\tau^j_{in}}{\tau^j_{ii}}} = \left(\frac{\pi^j_{nn}\pi^j_{ii}}{\pi^j_{ni}\pi^j_{in}}\right)^{1/2\theta^j}, \tag{1}$$

where θ^j is the cost-elasticity of trade and $\tau^j_{ni} \geq 1$ is the cost of importing good j from region i into region n.[3] Trade costs are iceberg, where τ^j_{ni} represents the quantity that must be shipped for one unit to arrive. The terms τ^j_{nn} and τ^j_{ii} capture the cost of trading *within* provinces.

How can one interpret the index's specific values? If $\bar{\tau}^j_{ni} = 1.5$ then we conclude it is 50% more costly to ship goods between n and i than it is to ship within those provinces. More precisely, it is 50% more costly to deliver one unit to n if $n \neq i$ than if $n = i$. We *cannot* conclude that trade costs are 50%. For example, if for an Alberta producer shipping to a destination within Alberta adds 20% to costs and shipping to an otherwise comparable destination in BC adds 80% (from additional regulatory compliance costs, perhaps), then we would estimate $\bar{\tau}^j_{ni} = 1.8/1.2 = 1.5$. Within-region trade costs τ_{nn} and τ_{ii} are not separately identified from between region costs. For precision, we refer to these estimates as *relative* trade costs.

To implement equation 1 using our trade share data, we require estimates of trade elasticities θ^j. Fortunately, there is a considerable research for us to draw on. We postpone a more detailed discussion of the literature to section 4.1. At this point, we take estimates from Caliendo and Parro (2015), aggregated up to our slightly smaller number of sectors. We report these elasticities in Table 9 in Appendix A; they range from 4.56 in food and textiles to 19.16 in chemicals and rubber (which includes refined petroleum products as well). With these, we construct relative trade cost measures $\bar{\tau}^j_{ni}$ and report their average values in the first column of Table 4. Overall, relative trade costs are 68% in Canada. The Atlantic provinces experience the largest costs (as high nearly 106% for shipments from PEI) while Quebec, Ontario, Alberta, and Saskatchewan experience the smallest (between 56-74%). As for sectors, services (education, health, and real estate in particular) have larger costs than most other sectors. For goods sectors, costs can still be substantial – with relative costs of 42% in food and textiles, or over 37% in equipment and vehicles. Though keep in mind that high relative costs for provinces or sectors may reflect low within-province costs.

2.3 Additional Trade Cost Measures

In addition to being expressed relative to within-province costs, there are two other limitations of these estimates. First, they are symmetric by construction. The estimated cost of exporting from Ontario to Alberta is the same as from Alberta to Ontario. Second, they are a broad measure reflecting *any* factor inhibiting trade – from actual trade costs to limited information or preference differences. Surely, much of the costs, such as distance and time costs, are likely beyond the

[3] Interested readers can derive this from our model in section 3; specifically, from equation 7.

Table 4: Average Trade Costs Within Canada

(a) By Exporting Province

	Relative Symmetric Costs	Exporter-Specific Trade Costs t_i^j	Contribution of Asymmetric Trade Costs	Contribution of Non-Distance Trade Costs
Alberta	56.1%	-15.5%	4.1%	7.2%
British Columbia	78.5%	-11.4%	6.0%	10.5%
Manitoba	74.0%	-4.8%	11.9%	9.8%
New Brunswick	66.4%	7.3%	16.4%	24.4%
Newfoundland	47.4%	-6.8%	14.4%	3.2%
Nova Scotia	85.4%	14.3%	19.0%	31.5%
Ontario	73.5%	-15.8%	1.3%	17.1%
Prince Edward Island	106.1%	22.2%	30.3%	32.1%
Quebec	62.5%	-1.4%	13.4%	17.4%
Saskatchewan	62.8%	11.9%	34.1%	14.3%
Canada	67.8%	0.0%	7.8%	14.5%

(b) By Industry

	Relative Symmetric Costs	Exporter-Specific Trade Costs t_i^j	Contribution of Asymmetric Trade Costs	Contribution of Non-Distance Trade Costs
Agriculture, Mining	24.4%	-25.7%	6.3%	-8.3%
Food, Textiles	42.0%	-21.0%	5.8%	-4.4%
Wood	24.9%	-14.4%	2.1%	3.6%
Paper	25.7%	-17.8%	3.4%	0.6%
Chemicals, Rubber	12.5%	-16.7%	1.9%	1.6%
Metals	63.2%	-2.8%	9.8%	11.8%
Equipment, Vehicles	37.4%	-17.0%	4.3%	3.1%
Manufacturing, n.e.c.	60.2%	-9.5%	4.8%	9.2%
Utilities	–	–	–	–
Construction	–	–	–	–
Wholesale and Retail	101.9%	-14.8%	6.6%	14.8%
Hotels and Restaurants	97.0%	3.4%	9.8%	29.4%
Transport	83.5%	-8.6%	10.8%	16.9%
Communication	84.8%	19.6%	12.2%	55.3%
Finance	91.7%	-5.0%	12.4%	36.2%
Real Estate	192.4%	8.4%	12.1%	57.8%
Software	132.3%	18.4%	19.7%	54.6%
Other Business Services	90.6%	-7.4%	8.1%	18.7%
Public Admin.	–	–	–	–
Education	230.0%	66.5%	15.5%	105.3%
Health and Social	245.8%	40.1%	16.7%	82.8%
Other Services	134.0%	17.1%	10.7%	44.5%

Reports the trade-weighted average relative trade cost, by exporting province (panel a) or by industry (panel b). All are trade-weighted averages across province pairs within Canada. Relative symmetric trade costs are from the Head-Ries Index (see equation 1. Asymmetric costs reported relative to the average. The third column displays trade costs relative to the no-asymmetry case (see equation 2). The fourth column uses a regression of trade costs on geographic distance (normalized by average within-province costs; that is, $d_{ni}/\sqrt{d_{nn}d_{ii}}$), with exporter and importer fixed effects. Construction and public administration have no trade. Utilities has only two trading pairs: AB-BC and NB-PEI, so we exclude it from the results.

control of policy makers. To help address these limitations, we explore two other measures that both exploit geographic distance between provinces.

First consider trade cost *asymmetries* between regions of Canada. These occur when it is more costly to trade in one direction (say, Alberta to Ontario) than it is in the other (say, Ontario to Alberta). To be sure, many trade costs are symmetric (distance and time costs, for example) but policies often burden trade in one direction but not another. There are a variety of examples, the simplest is perhaps an oil or gas pipeline. The flow goes in one direction, making it cheaper to move oil and gas in that direction than the other. A more complex example is the federal government's binding revenue ceiling on the two large Canadian rail carriers for shipments of regulated grain commodities from farmers in Alberta, Saskatchewan or Manitoba. This cap results in lower freight rates for farmers in those three western provinces, but not others. The rate to ship grain to Ontario from Alberta will therefore differ from the rate to ship from Ontario to Alberta. Finally, for goods broadly, provincial restrictions on the shipment of oversized loads differ. A carrier breaks down a load when entering an importing province with lower axle weight restrictions than the exporting province; in the reverse direction, this would not be the case.

Between countries, Waugh (2010) demonstrates trade cost asymmetries are often large and captured well by an exporter-specific component of trade costs. That is, if t^j_{ni} are symmetric trade costs between country n and i then $\tau^j_{ni} = t^j_{ni} t^j_i$, where t^j_i is an exporter-specific cost term. Tombe and Winter (2014) confirm this type of asymmetry is also important within Canada; they show nearly all trade cost asymmetry within Canada can be captured this way. This formulation also helps us abstract from within-province trade costs. Consider the following experiment: compare the current (unknown) trade costs τ^j_{ni} to the minimum trade cost between two provinces, regardless of the direction of flow; specifically,

$$\tau^j_{ni} / \min \left\{ \tau^j_{ni}, \tau^j_{in} \right\} = \max \left\{ 1, t^j_i / t^j_n \right\}. \tag{2}$$

This demonstrates that estimates of t^j_i are sufficient to know how trade costs τ^j_{ni} are enlarged by asymmetries; we need not know the actual level of τ^j_{ni}.

How can we estimate these exporter-specific costs? Intuitively, the procedure is simple. Proxy symmetric trade costs t^j_{ni} by geographic distance and regress trade flows on this distance along with importer and exporter fixed-effects. Waugh (2010) demonstrates the fixed-effect estimates are informative for trade cost asymmetries t^j_i. As we follow his procedure, we relegate details to Appendix B. Instead, we summarize the main results in columns 2 and 3 of Table 4. Trade cost asymmetries t^j_i are large and differ across sectors. Alberta, Ontario and Quebec typically have low export costs relative to other provinces while PEI, Manitoba, and Saskatchewan have the highest costs. In the industry panel, utilities, food, agriculture, business services, and transportation have the highest asymmetric costs while wholesale and retail trade and the equipment and vehicle sector have the lowest. Using equation 2, we report the average contribution of asymmetries to trade costs in the third column of panel (b). Overall, trade costs are nearly 8% larger due to trade cost asymmetries. While this is small relative to the value for $\bar{\tau}^j_{ni}$, we will later show even these small trade costs can have substantial effects on productivity and welfare.

Our second approach to isolate more policy-relevant costs also uses geographic distance. If trade costs are $\tau_{ni} = t_{ni}t_i$ then from equation 1 it is easy to show $\bar{\tau}^j_{ni} = \bar{t}^j_{ni}(t^j_i t^j_n)^{1/2}$, where $\bar{t}^j_{ni} = (t^j_{ni}t^j_{in}/\tau^j_{nn}\tau^j_{ii})^{1/2}$. As before, we proxy the average symmetric relative trade costs $\bar{t}^j_{ni}$ with geographic distance $\bar{d}_{ni} = d_{ni}/\sqrt{d_{nn}d_{ii}}$, which is the between-province distance relative to the average within-province distance (see Appendix B for details). To purge $\bar{\tau}^j_{ni}$ of variation related to geographic distance, estimate

$$ln(\bar{\tau}^j_{ni}) = \delta^j ln(\bar{d}_{ni}) + \iota^j_n + \eta^j_i + \epsilon^j_{ni}.$$

We report the results of this regression for each industry in Table 11 of Appendix B. The distance-elasticity of trade costs vary by sector, but are typically around 0.20. Trade costs unexplained by geographic distance are $(\bar{\tau}^j_{ni}/\bar{d}^{\hat{\delta}^j}_{ni}) - 1$. We refer to these as "non-distance trade costs", the average of which are in the fourth columns of Table 4. Distance explains much, though non-distance costs amplify overall relative trade costs in Canada by 15%.[4]

2.4 Trade and Input-Output Linkages

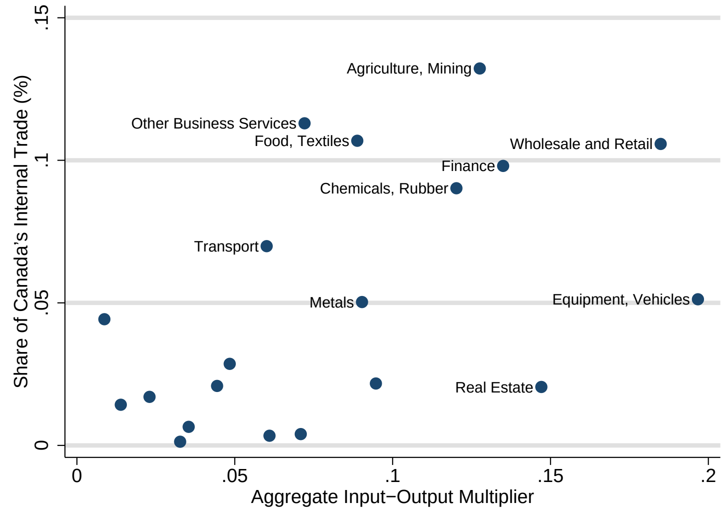
Input-output linkages between sectors will mean trade costs facing one industry cascade throughout the economy. After all, industries are not isolated from one another – output from one is used as inputs by others.

Are input-output linkages and trade related? To answer this question, consider the summary measure of a sector's "influence" discussed briefly in the introduction. Acemoglu et al. (2012), Jones (2013), Carvalho and Gabaix (2013), and others, demonstrate the effect of sectoral productivity shocks on the aggregate economy are summarized by a vector input-output multipliers $(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{\beta}$, where $(\mathbf{I} - \mathbf{A})^{-1}$ is the classic $J \times J$ Leontief Inverse Matrix and $\boldsymbol{\beta}$ is a $J \times 1$ vector of final demand shares. In proposition 2, we show the same expression holds for magnifying gains from trade. Using the OECD input-output data, we construct these multipliers in Appendix A; here, we display their relationship to trade in Figure 1. Primary producers within the agriculture and the mining and oil and gas sectors, along with producers in the chemicals, food, wholesale and retail trade, equipment and vehicle sectors are all highly traded sectors with significant influence on the aggregate economy. There are some exceptions. Real estate, for example, is a very important sector for aggregate GDP, but accounts for little internal trade. Overall, however, sectors that dominate Canada's internal trade systematically have higher input-output multipliers.[5]

[4]The negative trade costs for agriculture, mining are statistically different from zero, indicating distance more than accounts for trade costs in this sector. For chemicals, rubber (which includes refined petroleum products) the negative estimate is not different from zero.

[5]In Appendix A, we show sectors with high intermediate input shares also export a large share of output.

Figure 1: Internal Trade and Input-Output Multipliers



Note: Displays each industry's share of total internal trade in Canada against the industry's Input-Output Multiplier. This multiplier summarizes the "influence" of each sector on aggregate economic activity. This multiplier is defined as in Jones (2013): $(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{\beta}$, where $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ is the standard Leontief Inverse Matrix and $\boldsymbol{\beta}$ is a vector of final-demand shares (see text for details).

3 A Multi-Sector Model of Internal Trade

What are the consequences of internal trade costs for Canada's income and productivity? To answer this question, we must place more structure on the data using the Caliendo and Parro (2015) model featuring multiple sectors and rich input-output relationships. There are $N = 11$ regions, representing the 10 provinces of Canada plus the rest of the world. There is a single primary factor of production – say, labour. A sector's output can be consumed as a final good by a representative household in each region or used as an input into the production of other goods. Each sector's output is a composite of a continuum of tradable varieties, which are purchased from the cheapest source. The productivity with which each region can produce each variety differs, which is the basis for trade. With the broad setup in mind, let's move onto the details.

3.1 Households and Production

Consumers in region n consume J final goods to maximize

$$U_n = \prod_{j=1}^{J} C_n^{j\ \beta^j} \tag{3}$$

subject to a budget constraint $I_n = \sum_{j=1}^{J} P_n^j C_n^j$ and where $\sum_{j=1}^{J} \beta^j = 1$. It is straightforward to show the optimal household expenditures on good j is $P_n^j C_n^j = \beta^j I_n$. Household real income I_n / P_n, where $P_n = \prod_{j=1}^{J} P_n^{j\ \beta^j}$, therefore equals U_n. The same is true for region n's real GDP, so all welfare statements that follow apply equally well to real GDP.

To produce each good j, a perfectly competitive firm aggregates a continuum of intermediate input varieties using a CES technology

$$Y_n^j = \left(\int_0^1 y_n^j(\omega)^{\frac{\sigma^j - 1}{\sigma^j}} d\omega \right)^{\frac{\sigma^j}{\sigma^j - 1}}, \tag{4}$$

where σ^j is the elasticity of substitution and $y_n^j(\omega)$ is the amount of variety ω used by sector j in region n. Each intermediate can be sourced from producers within region n or imported from another – whichever is cheaper. Final goods may be consumed directly by households or used as an input into the production of each individual intermediate variety. We denote $m_n^{jk}(\omega)$ the amount of final good Y_n^k used in the production of intermediate variety ω in sector j.

Individual varieties are produced using labour $L_n^j(\omega)$ and materials $m_n^{jk}(\omega)$ with

$$y_n^j(\omega) = \varphi_n^j(\omega) L_n^j(\omega)^{\phi^j} \prod_{k=1}^{J} m_n^{jk}(\omega)^{\gamma^{jk}(1-\phi^j)}. \tag{5}$$

Value-added share of output is ϕ^j and the share of intermediate inputs in sector j from sector k is γ^{jk}. Primary inputs include more than just labour and we presume that they are all perfectly mobile across sectors but cannot move across regions. We explore factor mobility in Appendix D. Notice also that we abstract from factor accumulation; our analysis is therefore static.

Perfectly competitive input markets, and the Cobb-Douglas structure of the production technology, implies the cost of an input bundle is

$$c_n^j \quad \propto \quad w_n^{\phi^j} \prod_{k=1}^{J} \left(P_n^k \right)^{\gamma^{jk}(1-\phi^j)}, \tag{6}$$

where w_n is the price of primary inputs (say, wages) and P_n^j is the price of sector j's final good. Neither depends on the purchasing sector. The producer price for a particular variety with productivity $\varphi_n^j(\omega)$ is therefore $c_n^j / \varphi_n^j(\omega)$.

3.2 Expenditures, Prices, and Trade Patterns

With marginal costs known and a perfectly competitive market structure, we know that producers charge $P_i^j(\omega) = c_i^j / \varphi_i^j(\omega)$. Price differences across firms results from differences in productivity. Following Eaton and Kortum (2002), φ follows a Fréchet distribution $F_n^j(\varphi) = e^{-T_n^j \varphi^{-\theta^j}}$, where the parameter θ^j governs productivity variation (larger θ^j gives lower variation) and T_n^j governs average productivity. Finally, shipping across regions (say, from i to n) incurs an iceberg trade cost $\tau_{ni}^j \geq 1$; within a country $\tau_{nn}^j = 1$.[6] The consumer price is therefore $P_{ni}^j(\omega) = \tau_{ni}^j c_i^j / \varphi_i^j(\omega)$.

[6]This normalization is innocuous, as τ_{nn}^j can be a component of provincial productivity T_n^j. However, this does affect the *interpretation* of our quantitative exercises. We will be clear on this point at the end of section 3.3.

With this distribution, Eaton and Kortum (2002) show the fraction of region n spending on good j allocated to producers in region i, denoted π^j_{ni}, is

$$\pi^j_{ni} = \frac{T^j_i \left(\tau^j_{ni} c^j_i\right)^{-\theta^j}}{\sum_{k=1}^{N+1} T^j_k \left(\tau^j_{nk} c^j_k\right)^{-\theta^j}}, \tag{7}$$

and the price index of good j in region n is

$$P^j_n = \gamma^j \left[\sum_{i=1}^{N+1} T^j_i \left(\tau^j_{ni} c^j_i\right)^{-\theta^j}\right]^{-1/\theta^j}, \tag{8}$$

where $\gamma^j = \Gamma(1 + (1 - \sigma^j)/\theta^j)^{1/(1-\sigma^j)}$ and $\Gamma(\cdot)$ is the Gamma function. Importantly, for these expressions to hold, the parameter θ^j may vary across industries but not across regions.

Given total expenditures (by households and firms) on final good j in region n, denoted X^j_n, total exports of good j from n to i is therefore $X^j_{in} = \pi^j_{in} X^j_i$. In addition to exports, domestic sales also contribute to firm revenue. Combine total domestic sales $\pi^j_{nn} X^j_n$ and total exports $\sum_{i \neq n} \pi^j_{in} X^j_i$ to yield

$$R^j_n = \sum_{i=1}^{N} \pi^j_{in} X^j_i. \tag{9}$$

Given the Cobb-Douglas production technologies, a fraction ϕ^j of this revenue will go to primary factors. With no other source of income for the household, we have

$$I_n = \sum_{j=1}^{J} \phi^j R^j_n. \tag{10}$$

Global income also serves as our numeraire, as is common in these models, so $\sum_{n=1}^{N+1} I_n = 1$.

Finally, goods market clearing implies $Y^j_n = C^j_n + \sum_{k=1}^{J} m^{kj}$ and therefore

$$X^j_n = \beta^j I_n + \sum_{k=1}^{J} (1 - \phi^k) \gamma^{kj} R^k_n. \tag{11}$$

While not explicitly imposed, the following proposition demonstrates a region's total exports will equal its total imports – aggregate trade will balance.

Proposition 1 *Trade may not balance at the sector level, but aggregate trade balances in all regions.*

Proof: See appendix.

Overall trade balance will prove convenient for a number of derivations to come. In the quantitative analysis, trade balance is not an important property for our results. In Appendix D, we show aggregate trade imbalances do not change our results.

3.3 Relative Changes

To ease the calibration and quantitative analysis, we use the "Exact-Hat Algebra" approach of Dekle, Eaton and Kortum (2007). The simulated equilibrium responses to a change in model primitives turns out to be very straightforward. In all that follows, denote $\hat{x} = x'/x$ as the relative change between a counterfactual value of some variable x' and its initial value x. For example, $\hat{\tau}^j_{ni}$ denotes the change in the cost of region n importing sector j goods from region i. If, for example, $\hat{\tau}^j_{ni} = 0.9$ then trade costs are 90% of their initial level.

From equation 6, the relative change in input costs are

$$\hat{c}^j_n \quad = \quad \hat{w}_n^{\phi^j} \prod_{k=1}^{J} \left(\hat{P}^k_n\right)^{\gamma^{jk}\left(1-\phi^j\right)}. \tag{12}$$

With this, equations 7 and 8 provide counterfactual trade shares

$$\pi^j_{ni}{}' = \frac{\pi^j_{ni}\left(\hat{\tau}^j_{ni}\hat{c}^j_i\right)^{-\theta^j}}{\sum_{k=1}^{N+1}\pi^j_{nk}\left(\hat{\tau}^j_{nk}\hat{c}^j_k\right)^{-\theta^j}}, \tag{13}$$

and the relative change in prices are

$$\hat{P}^j_n = \left[\sum_{i=1}^{N+1}\pi^j_{ni}\left(\hat{\tau}^j_{ni}\hat{c}^j_i\right)^{-\theta^j}\right]^{-1/\theta^j}. \tag{14}$$

The above three expressions are sufficient to solve $\left(\hat{P}^j_n, \hat{c}^j_i, \pi^j_{in}{}'\right)$ given wage changes $\hat{w}_n$ and the exogenous change in trade costs $\hat{\tau}^j_{ni}$. What remains is to solve for equilibrium changes in wages for each region. As before, equations 9 through 11 solve for counterfactual revenue, expenditures, and income given the counterfactual trade shares. As $w_n L^j_n = \phi^j R^j_n$, equation 10 implies $\hat{I}_n = \hat{w}_n$. Thus, equations 9 to 14 provide a mapping from exogenous change in trade costs $\hat{\tau}^j_{ni}$ to counterfactual values for costs, prices, trade shares, and wages.

Importantly, the productivity parameter T^j_n, total labour supply L_n, and initial trade cost levels τ^j_{ni} are absent from these expressions. In any counterfactual where τ^j_{ni} changes (where $\hat{\tau}^j_{ni} \neq 1$), the productivity parameter T^j_n and the labour supply L_n must remain constant. This dramatically simplifies the calibration and simulation of the model and ensures many of our quantitative results are independent of the trade cost estimates from section 2.3, as it is only $\hat{\tau}^j_{ni}$ that matters. That being said, we must take care when interpreting the results. In particular, a consequence of the common normalization $\tau^j_{nn} = 1$ is that within-province trade costs τ^j_{nn} are a component of provincial productivity. If trade costs within-provinces were to change by $\hat{\tau}^j_{nn}$ then it would be as if $\hat{T}^j_n = \hat{\tau}^{j\ -\theta^j}_{nn}$. Consequently, none of our experiments should be interpreted as altering τ^j_{nn}. Improved fuel-economy of trucks, for example, would reduce both τ^j_{ni} and τ^j_{nn}. The trade cost changes we have in mind are regulatory barriers that make *crossing a provincial boundary* more expensive. Constant provincial labour supply is more easily dealt with: in Appendix D, we expand the model to allow for labour mobility.

3.4 Aggregate Outcomes

In our quantitative exercises, we measure the effect of trade costs on regional and aggregate welfare and sectoral real labour productivity, defined through the following propositions. As labour is perfectly mobile between sectors, labour productivity and real wages are related by $Y_n^j/L_n^j = (w_n/P_n^j)/\phi^j$. Changes in real wages $\hat{w}_n/\hat{P}_n^j$ therefore equal changes in sectoral labour productivity.

Proposition 2 *Let* $\mathbf{G}$ *denote an* $J \times N$ *matrix of (log) real wage changes for each region and sector implied by an Eaton-Kortum model without input-output relationships, with elements* $-log(\hat{\pi}_{nn}^j)/\theta^j$. *In the model with input-output relationships, (log) real wage changes are*

$$\tilde{\mathbf{G}} = (\mathbf{I} - \mathbf{A}')^{-1}\mathbf{G},$$

where $(\mathbf{I} - \mathbf{A})^{-1}$ *is the* $J \times J$ *Leontief Inverse Matrix. In addition, (log) welfare changes are*

$$\hat{\mathbf{U}} = \mathbf{G}'(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta},$$

where $\boldsymbol{\beta}$ *is a* $J \times 1$ *vector with elements* β^j.

Proof: See appendix.

This proposition provides a powerful and intuitive way to capture the magnification effect input-output relationships have on gains from trade. In a large class of (single-sector) models, Arkolakis et al. (2012) demonstrate welfare gains from trade are $\hat{\pi}_{nn}^{-1/\theta}$. The above proposition demonstrates these standard gains are simply collected across all sectors and amplified by a single vector of input-output multipliers. The multipliers here are a common summary measure of a sector's "influence" on the aggregate economy; similar to the TFP Multipliers in Jones (2013) or the Influence Vector in Acemoglu et al. (2012) and Carvalho and Gabaix (2013).While not an entirely novel expression – it is, for example, identical to a special case of equation 28 in Costinot and Rodriguez-Clare (2014) and can be derived from a version of Caliendo and Parro (2015) – the explicit link to the recent input-output literature is instructive. The multipliers $(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta}$ can be calculated from readily available Input-Output Tables; they are listed in Table 9 of Appendix A.

Given changes in welfare at the province level, the following proposition determines the average (national) welfare change for Canada.

Proposition 3 *The change in national welfare is* $\hat{U} = \boldsymbol{\omega}'\hat{\mathbf{U}}$, *where* $\boldsymbol{\omega}$ *is an* $N \times 1$ *vector of initial shares of national real GDP for each region.*

Proof: See appendix.

4 Quantitative Analysis

In this section, we quantify the effect of trade costs on various economic outcomes, particularly regional and aggregate welfare and sectoral labour productivity. Of course, our quantitative analysis is model specific – other trade models may yield different results. That being said, the model we use is within the family of workhorse models common to quantitative international trade research. For a general exploration of these models, see Costinot and Rodriguez-Clare (2014).

4.1 Calibration

We must first calibrate the various model parameters $(\theta^j, \gamma^{jk}, \beta^j, \phi^j, \omega_n, \pi^j_{ni})$, many of which have observable counterparts in data. Production technology parameters $\left(\gamma^{jk}, \phi^j\right)$ and final demand shares β^j are set to match input-output data from the OECD Structural Analysis database. The initial share of national real GDP ω_n is necessary *only* to calculate counterfactual aggregate welfare changes in proposition 3. Provincial real GDP is readily available data. We provide detailed description of all of production and GDP data, and the specific parameter values we find, in Appendix A. Finally, initial equilibrium trade shares π^j_{ni} are as described in section 2.2.

The only parameter that cannot be set to match data is θ^j, which governs productivity dispersion and, from equation 7, the cost-elasticity of trade flows. There is a large literature estimating this elasticity across countries, with typical estimates of θ around 4 or 5 (see Head and Mayer, 2014, for a review). Unfortunately, we are unaware of any within-country sector-specific estimates, and – lacking detailed product prices across regions, which is what elasticity estimates typically require – we do not estimate our own θ^j. Instead, we turn to the international trade literature. Caliendo and Parro (2015) estimate elasticities at a level of aggregation useful for our purposes. We adopt their estimates where possible and – as in Costinot and Rodriguez-Clare (2014) – set $\theta = 5$ for all other sectors. See Table 9 in Appendix A for details.

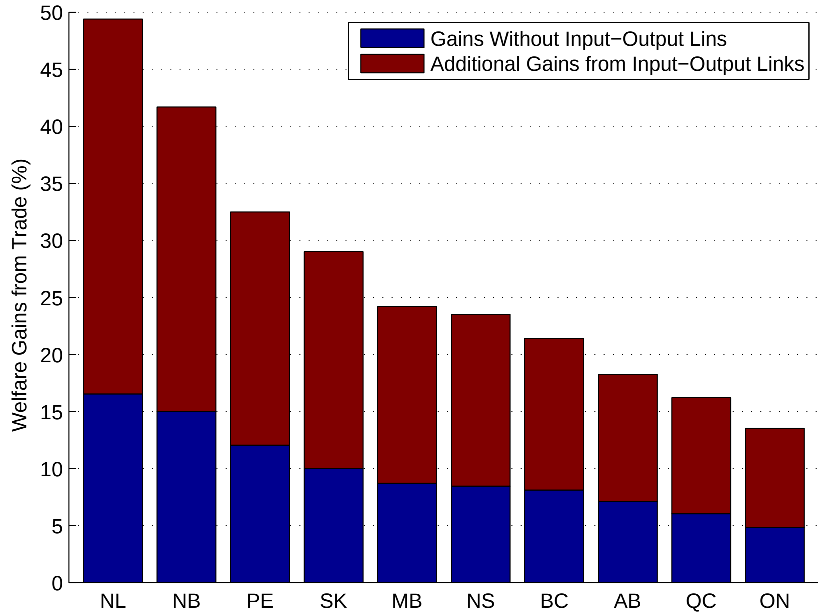
4.2 The Gains from Current Trade Flows

We begin by quantifying the effects of Canada's current level of internal and overall trade, by sector and province. This is – by far – the simplest counterfactual experiment and is widely used to benchmark international trade models. The experiment is the following: compare welfare in given the *current, observed* trade shares π^j_{ni} to welfare in an autarky counterfactual where $\pi^j_{ni} = 1$ for all $n \neq i$. In this exercise, the equilibrium change in trade shares $\hat{\pi}^j_{ni}$ moving from autarky to the current level of trade is π^j_{ni}. From proposition 2, we have $\hat{\mathbf{U}} = \mathbf{G}'(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta}$ where the the elements of the $J \times N$ matrix $\mathbf{G}$ are $-log(\pi^j_{nn})/\theta^j$.

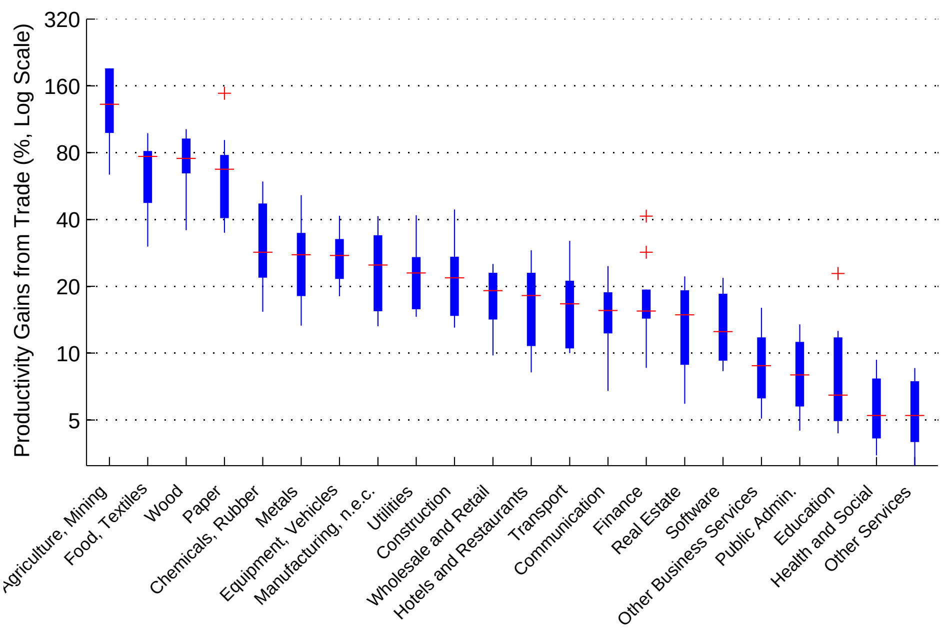
Consider first the gains from trade by province. In Figure 2, we plot the welfare gains for each province. The lower blue bars mark the gains from a model without intermediate input linkages, which is just $\mathbf{G}'\boldsymbol{\beta}$. Overall, these gains are less than 7%. With input-output linkages, these gains are magnified substantially, with national gains over 18%. Input-output linkages *must* increase the gains from trade, since $(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta}$ is everywhere greater than $\boldsymbol{\beta}$.

Figure 2: The Gains from Trade

(a) Welfare (Real GDP) Gains, by Province



(b) Labour Productivity Gains, By Industry



Note: Displays the provincial welfare (top) and industry productivity (bottom) relative to an autarky counterfactual. Welfare and real GDP are synonymous in our framework. Panel (a) displays results with and without input-output relationships. In Panel (b), productivity gains for each industry-province pair are displayed as a boxplot across industries. The red horizontal line within each blue bar is the median productivity change across provinces for each industry.

Table 5: Aggregate Welfare, Gains from Trade and Sensitivity to τ_{ni}^{j}

	Gains from Trade			10% Lower τ_{ni}^{j}	
	All	Internal	External	Internal	External
Alberta	18.3%	4.7%	9.3%	3.6%	2.5%
British Columbia	21.4%	4.7%	10.9%	3.9%	2.9%
Manitoba	24.2%	8.1%	8.0%	6.0%	2.5%
New Brunswick	41.7%	8.1%	12.2%	6.5%	4.7%
Newfoundland	49.4%	7.7%	12.0%	6.6%	3.0%
Nova Scotia	23.5%	7.5%	8.9%	6.1%	3.0%
Ontario	13.5%	3.2%	8.7%	2.6%	3.1%
Prince Edward Island	32.5%	11.4%	10.1%	7.2%	2.1%
Quebec	16.2%	4.2%	8.9%	3.5%	2.9%
Saskatchewan	29.0%	7.1%	11.8%	5.2%	3.0%
Canada	18.3%	4.4%	9.3%	3.6%	2.9%

Results of counterfactuals that are independent of trade cost levels. "Gains from Trade" is the welfare change *relative to no-trade*: complete autarky (column 1), internal trade only (column 2), or international trade only (column 3). The elasticities of aggregate welfare with respect to τ_{ni}^{j} (for internal trade and international trade) are in columns 4 and 5, which simulate $\hat{\tau}_{ni}^{j} = 0.9$.

At the industry level, gains from trade are also substantial, though there are extremely large differences across industries. From proposition 2, the change in industry productivity by province is given by the matrix $(\mathbf{I} - \mathbf{A}')^{-1}\mathbf{G}$. In panel (b) of Figure 2, we plot each industry's productivity in each province relative to the autarky counterfactual. The gains vary across provinces for a given industry, and this box and whiskers plot captures that variation. The blue bars reflect the inter-quartile range while the red lines within the blue bars denote the median change. Some industries, including agriculture, mining, food, textiles, and chemicals (which includes refined petroleum) have substantial productivity gains – averaging more than 50%.

The above results compare observed trade to complete autarky – which includes no international trade. What about the gains from *internal* trade only? Imagine the counterfactual where the relative change in trade costs between Canadian provinces are $\hat{\tau}_{ni}^{j} = \infty$ for all $n \neq i$ and $(n, i) \neq N$, and $\hat{\tau}_{ni}^{j} = 1$ otherwise. The gains from internal trade is then $\hat{U}^{-1}$. This exercise will gauge the contribution to welfare and productivity from the current level of internal trade in Canada. We report all welfare changes in Table 5. We find aggregate gains of 4.4%, much lower than the overall gains from trade as international trade is still available, though most of the lost internal trade is made up by increasing production within each province for domestic use. In fact, we find international trade increases by only 9% and the share purchased from within-province producers π_{nn}^{j} rises by 30%. We also see the earlier pattern that poor provinces – especially Prince Edward Island, New Brunswick, Manitoba – gain more, all around 8%, than rich provinces, such as Ontario who gains 3.2%. Internal trade, therefore, reduces regional income and productivity differences.

Finally, gains from *international* (external) trade are typically larger than the gains from internal trade. As with the experiment shutting down internal trade, consider the experiment where $\hat{\tau}_{ni}^{j} = \infty$ for all $i = N$ or $n = N$, and $\hat{\tau}_{ni}^{j} = 1$ otherwise. The third column of Table 5 reveals

Canada's aggregate welfare (real GDP) is 9.3% higher compared to the case of no international trade. Gains for most provinces are around this level, varying from a low of 8% (Manitoba) to a high of 12.2% (New Brunswick). Internal trade rises in response, offsetting some of the loss, though given the large share of expenditure allocated to producers abroad it is not surprising gains from international trade exceed gains from internal trade.

4.3 The Gains from Lower Trade Costs

One must interpret the previous results with caution, as they do not depend on our measures of trade costs from section 2. While a valuable property, they give no indication of the potential scope for (and gains from) liberalization efforts by policy makers. In this section, we explicitly consider the consequences of our measured trade costs on welfare and productivity.

First, a useful benchmark is the *elasticity* of welfare with respect to τ^j_{ni}. Consider a counterfactual where $\hat{\tau}^j_{ni} = 0.9$ for all sectors j and all region pairs $n \neq i$ and $(n,i) \neq N$, and $\hat{\tau}^j_{ni} = 1$ otherwise.[7] We display the aggregate results in Table 5, though postpone a more detailed discussion to Appendix B. The gain of 3.6% following a 10% reduction in τ^j_{ni} between provinces reveals small reductions in trade costs can have substantial gains. What is the underlying source of these gains? Trade costs take an iceberg form where goods melt away while in transit from one location to another. As emphasized by Fan et al. (2014), gains from lower trade costs are – to a first approximation – equal to the value of traded goods that no longer melt. That is, if inter-provincial trade volumes are 21% of GDP (as in our data) then a one percentage point reduction in trade costs increases aggregate welfare by 0.21%.

This leads us to an important caveat: the trade cost reductions in the upcoming simulations all involve reducing iceberg trade costs. Our results are therefore most relevant if actual policy-relevant trade costs in Canada involve physical costs incurred on each good shipped. To the extent that they do not, our estimates may overestimate the gains.

4.3.1 10% Lower Measured Trade Costs

First, we can reduce internal trade costs in a way that takes advantage of our Head-Ries index $\bar{\tau}^j_{ni}$. First, with our estimates of exporter-specific trade costs t^j_i, define an augmented Head-Ries index $\tilde{\tau}^j_{ni} = \bar{\tau}^j_{ni}(t^j_i/t^j_n)^{1/2} = \tau^j_{ni}(\tau^j_{nn}\tau^j_{ii})^{-1/2}$. While we do not have estimates of τ^j_{ni} independent of within-province costs τ^j_{nn} and τ^j_{ii}, it is straightforward to show

$$\hat{\tau}^j_{ni} = \frac{1 + 0.9 \times (\tilde{\tau}^j_{ni} - 1)}{\tilde{\tau}^j_{ni}} = \frac{0.9 \times \tau^j_{ni} + 0.1 \times (\tau^j_{nn}\tau^j_{ii})^{1/2}}{\tau^j_{ni}}. \tag{15}$$

[7] One can also consider $\hat{\tau}_{ni} = 0.9$ as reducing the between-province trade costs by z percentage points to $\tau'_{ni} = \tau_{ni} - z$, where $z = 0.1 \times \tau_{ni}$. So while $\hat{\tau}_{ni} = 0.9$ for all pairs within Canada, the effective liberalization implied by this experiment varies across pairs. Since $\tau_{ni} = 1$ implies zero trade costs, it is important to note that this experiment only makes sense if $\tau_{ni} \geq 10/9$.

Table 6: Welfare (Real GDP) Gains from Trade Liberalization

	10% Lower Trade Costs ($\tilde{\tau}^j_{ni} - 1$)		Eliminate Certain Internal Trade Costs		
	Internal	External	Asymmetric	Non-Distance	All Internal
Alberta	0.9%	1.6%	2.4%	5.5%	51.1%
British Columbia	1.0%	2.0%	2.8%	4.9%	64.6%
Manitoba	1.6%	2.0%	5.2%	8.4%	108.2%
New Brunswick	1.8%	2.5%	8.0%	28.3%	130.8%
Newfoundland	1.8%	1.8%	5.0%	23.5%	125.1%
Nova Scotia	1.8%	2.2%	7.9%	24.3%	142.0%
Ontario	0.6%	1.8%	2.8%	3.2%	26.8%
Prince Edward Island	2.7%	2.3%	18.6%	35.1%	285.4%
Quebec	0.8%	1.8%	2.5%	7.1%	45.0%
Saskatchewan	1.4%	2.4%	8.7%	17.2%	88.8%
Canada	0.9%	1.8%	3.3%	6.8%	51.9%

For various experiments, displays change in welfare for each province and Canada's overall change. The first two columns report results of reducing measured trade costs by 10%; that is, $\hat{\tau}^j_{ni} = (1 + (\tilde{\tau}^j_{ni} - 1) \times 0.9)/\tilde{\tau}^j_{ni}$, where $\tilde{\tau}^j_{ni}$ is a Head-Ries index augmented to reflect export costs (see section 4.3.1 for details). The last three columns report eliminating various components of measured trade costs. Removing asymmetries involves $\hat{\tau}^j_{ni} = \min(1, \tau^j_{in}/\tau^j_{ni})$. Eliminating non-distance costs involves reducing bilateral costs to what is explained by a regression of trade costs on geographic distance. Eliminating all internal trade costs involves $\hat{\tau}^j_{ni} = 1/\tilde{\tau}^j_{ni}$. See section 2.3 for the various trade cost estimates.

We can therefore simulate the effect of reducing the between-province costs τ^j_{ni} to a level 10% of the distance to the average within-province costs $(\tau^j_{nn}\tau^j_{ii})^{1/2}$. We report the results in Table 6.

Welfare gains average around 1% across provinces, with poor provinces typically gaining much more than rich. Overall, Canada's aggregate welfare (real GDP) increases 0.9% following a 10% reduction in trade costs – equivalent to roughly \$17 billion. For comparison, when international trade costs decline by 10%, aggregate welfare increases by 1.8%.[8] We also find internal and international trade flows are substitutes. When internal trade costs fall by 10%, international trade volumes decline by over 1.4% while internal trade volumes increase by 19%. When international trade costs fall by 10%, internal trade falls by 7% while international trade increases 23%.

These gains depend crucially on input-output relationships. From proposition 2, welfare gains depend on two things: (1) the trade response $\hat{\pi}^j_{nn}$ and (2) the input-output multiplier $(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta}$. The presence of input-output linkages will affect both. Consider first changes in gains *for a given trade response* – that is, for a given $\hat{\pi}^j_{nn}$. If labour were the only input ($\phi^j = 1$ for all j) and all production was for final goods, the multiplier would fall to $\boldsymbol{\beta}$ (since $\mathbf{A}$ is the zero matrix in this case). With the lower multiplier, aggregate gains from 10% lower internal trade costs are only 0.33%. If instead we allows for limited input-output relationships, where firms can only use as inputs goods from their own sector then $\mathbf{A}$ is a matrix with zeros everywhere except along the diagonal, where the j^{th} element is $1 - \phi^j$. Equivalently, the multiplier is $\boldsymbol{\beta} \oslash \boldsymbol{\phi}$ with elements β_i/ϕ_i. In this case, gains are 0.69%. The trade response, however, will differ in models with

[8] As we estimate exporter-specific costs only for Canadian provinces, we use $\bar{\tau}^j_{ni}$ instead of $\tilde{\tau}^j_{ni}$ when reducing international trade costs by 10%.

different structure. Solving for $\hat{\tau}_{ni}^{j}$, we find gains in the labour-only case of 0.36% (compared to the 0.33% found above) and in the no between-sector purchases case of 0.68% (compared to 0.69%). Thus, the input-output multipliers $(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta}$ provides a good measure of how models with and without input-output linkages will differ. To summarize, roughly 40% of gains are from final goods, 40% from own-sector intermediates, and the remaining 20% from inter-sectoral linkages.

4.3.2 Industry-by-Industry Liberalization

What are the effects of reducing trade costs one industry at a time? This is a useful question to explore as policy makers in Canada typically tackle internal trade reform on a sector-by-sector basis. For example, the Eleventh Amendment to the Agreement on Internal Trade focused on agricultural products and the Fifth Amendment (among others) deals with government procurement. Unifying Canada's securities regulations is another example of a sector-specific reduction in inter-provincial barriers to trade. We simulate the effect of liberalizing industries individually, using equation 15 to define $\hat{\tau}_{ni}^{j}$ for each j while holding trade costs in all other industries constant. Figure 3 display the results.

There are large differences across industries in the effect of a 10% reduction in their trade costs on aggregate welfare. Reducing trade costs by 10% in the wholesale and retail sector yields the largest gain in aggregate welfare – nearly 0.14% (over $2.6 billion). Gains of a similar magnitude result from reducing trade costs in agriculture and mining, finance, or food and textile sectors. These are all highly interconnected sectors, as well saw earlier. Trade costs facing those sectors will have a disproportionately negative aggregate effect. To see this, we plot the gains against each sector's input-output multiplier – it displays a clear positive relationship, although equipment and vehicles have relatively lower costs and therefore smaller gains. These results suggest that efforts by policy makers to harmonize trucking regulations or to consolidate Canada's securities regulators into a single Federal agency appear to be well targeted. On the other end of the spectrum, liberalizing education, health, construction, or telecommunications appear to have little effect on aggregate welfare. If political constraints demand a piecemeal approach to liberalization, highly interconnected sectors are where to start.

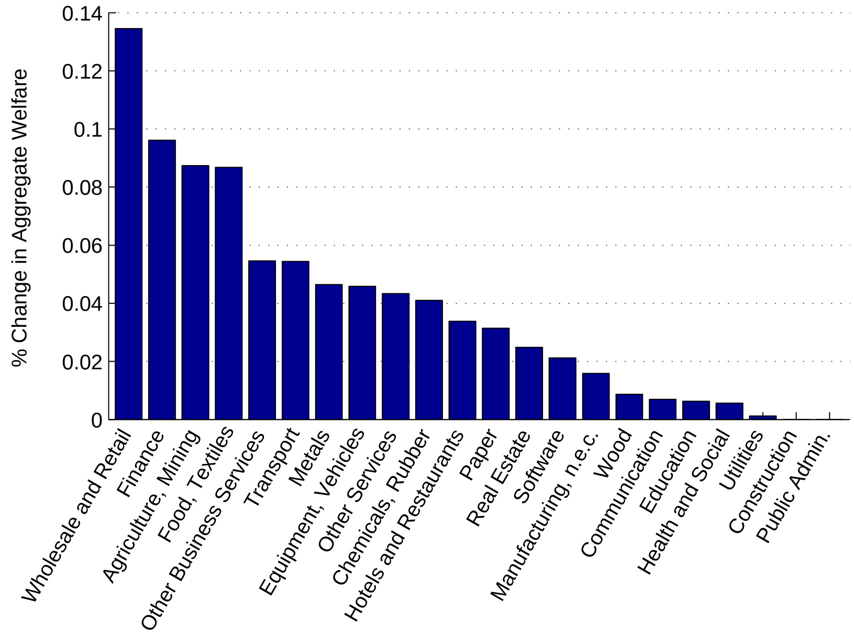
4.3.3 Other Informative Experiments

Reducing trade costs by 10% in the previous exercises is, of course, arbitrary. Larger reductions result in higher gains. Reducing internal trade costs across all sectors in half, for example, increases aggregate welfare by 7.6%%. How large of a trade cost reduction is reasonable for policy makers? In this section, we explore a few answers to this question as well as some other informative experiments. The key results are in Table 6.

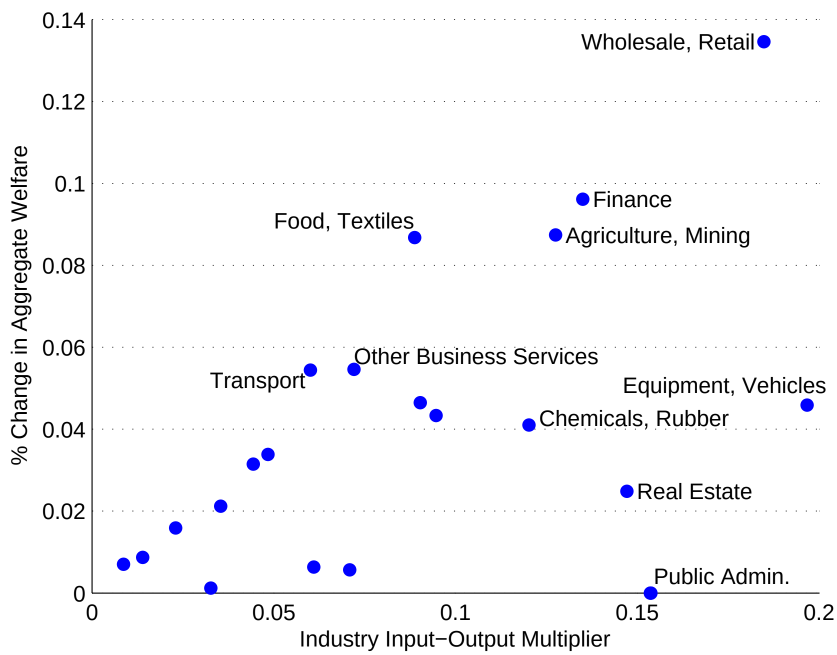
First, trade cost asymmetries are likely to reflect factors that policy makers can influence. If trade costs are larger when goods within the same industry move from Ontario to Manitoba than when those same goods move from Manitoba to Ontario, then something beyond simple geo-

Figure 3: Welfare (Real GDP) Gains from Individually Liberalizing Industries

(a) 10% Lower Trade Costs, by Industry



(b) Welfare Gains vs. Input-Output Multipliers



Note: Displays the effect of reducing measured internal trade costs in each industry – one at a time – by 10%. Specifically, separately for each j, we simulate $\hat{\tau}^j_{ni} = (1 + 0.9 \times (\tau^j_{ni} - 1))/\tau^j_{ni}$. Panel (a) reports the gains for each industry, in decreasing order of gains. Panel (b) plots these gains against each industry's input-output multipliers $(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{\beta}$.

graphic distance, time, or information costs are involved. To measure the consequences of these asymmetries on welfare, we consider a counterfactual where $\hat{\tau}^j_{ni} = \min(1, t^j_n / t^j_i)$, which follows from equation 2. This reflects changing trade costs between two provinces to the minimum observed cost in either direction. The gains are substantial, with aggregate gains of 3.3% – equivalent to a real GDP gain of $57 billion.

Our second approach to estimating the effect of policy-relevant costs involved purging the Head-Ries measure of variation related to geographic distance between trading partners. Overall, these residual non-distance factors amplify average trade costs in Canada by nearly 15%. The welfare gains from removing those costs are smaller than removing cost asymmetries, but still 6.8% (equivalent to $130 billion). The Atlantic provinces, as before, gain substantially more than the others. Consequently, regional income variation in this experiment decline by 1.2%. This, and the previous gains from removing trade cost asymmetries, are strongly suggestive that the gains from further internal trade reform in Canada are substantial.

Next, consider the counterfactual of zero relative trade costs. For this, we would ideally simulate $\hat{\tau}^j_{ni} = 1/\tau^j_{ni}$ though we do not have a direct measure of τ^j_{ni}. Instead, we simulate $\hat{\tau}^j_{ni} = 1/\tilde{\tau}^j_{ni}$, where $\tilde{\tau}^j_{ni}$ is the augmented Head-Ries index described in section 4.3.1. This exercise reduces all between-province costs between n and i to the average of their within-province costs $(\tau^j_{nn}\tau^j_{ii})^{1/2}$. The counterfactual aggregate welfare is 52% higher than the initial equilibrium. At the province level, gains can be as high as 285% for PEI and most provinces see gains of well over 100%. The smallest gains are in Ontario, where welfare rises by only one-quarter.

Finally, the Canadian province of Quebec periodically experiences strong political support for separation from the rest of Canada. Debates surrounding common currency or a customs union typically feature prominently in public discussions of the economic consequences of separation. How would an increase in trade costs between Quebec and the rest of Canada affect welfare? We investigate the counterfactual where $\hat{\tau}^j_{ni} = 1.1$ if n or i is Quebec, and $\hat{\tau}^j_{ni} = 1$ otherwise. Every province loses from this event, with loses varying between 0.5% for Ontario to 0.2% for Alberta. Quebec, of course, loses the most, with welfare in that province falling by 4.8%.

5 Conclusion

International trade, and its costs, receives substantial attention by researchers, policy makers, and the public at large; in contrast, internal trade receives little. For Canada, internal trade is nearly as large as international trade and – despite the lack of explicit tariffs – internal trade still faces substantial costs. Recently, there is a renewed push among policy makers in Canada to reduce these (mainly regulatory) costs. As reform is often sector-by-sector, we flexibly measure trade costs, and the gains from liberalization, at the industry level. To quantify the consequences of these internal trade costs, we use a recent quantitative theoretical framework featuring multiple interconnected industries (Caliendo and Parro, 2015).

The gains from reducing internal trade costs are large. On average, reducing internal trade costs by 10% increases aggregate welfare by 0.9% – equivalent to over $17 billion. Various measures of policy-relevant trade costs reveals large scope for liberalization, with large aggregate gains. For example, trade cost asymmetries (where costs to import goods from Alberta into Ontario differ from costs to import goods from Ontario into Alberta) increase the cost of trading between provinces by roughly 8%. We estimate that removing these costs would increase Canada's aggregate welfare by over 3%. Even larger, we estimate trade costs unrelated to distance of nearly 15%, with welfare rising almost 7% by their elimination. Interconnections between industries through input-output linkages matter. First, they amplify gains from trade and the aggregate consequences of trade costs. Second, and more important for our purposes, sectors with large input-output multipliers – such as chemicals (which includes refined products), agriculture, mining, food, textiles, and finance – yield the largest gains from unilateral liberalization. Reducing trade costs in the finance industry by 10%, for example, increases aggregate welfare by 0.1%. This matters, as policy makers often take a sector-by-sector approach to reform.

Overall, trade costs within Canada are large, as are the gains from reducing these costs. Our estimates suggest internal trade liberalization could add $50-$130 billion to Canada's overall GDP – in line with the government's own estimates of $50 billion in potential gains. Improving the internal flow of goods and services within Canada should therefore be a priority.

References

Acemoglu, Daron, Vasco Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi, "The Network Origins of Aggregate Fluctuations," *Econometrica*, 2012, *80* (5), 1977–2016.

Agnosteva, Delina, James Anderson, and Yoto Yotov, "Intra-national Trade Costs: Measurement and Aggregate," 2014.

Anderson, James E. and Yoto V. Yotov, "The Changing Incidence of Geography," *American Economic Review*, 2010, *100* (5), 2157–86.

Arkolakis, Costas, Arnaud Costinot, and Andres Rodreguez-Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, *102* (1), 94–130.

Balassa, Bela, "Trade Liberalisation and "Revealed" Comparative Advantage," *The Manchester School*, 1965, *33* (2), 99–123.

Beaulieu, Eugene, James Gaisford, and Jim Higginson, *Interprovincial trade barriers in Canada: How far have we come? Where should we go?*, Van Horne Institute, 2003.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *Review of Economic Studies*, 2015, *82*, 1–44.

_ , _ , Esteban Rossi-Hansberg, and Pierre-Daniel Sarte, "The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy," 2014.

Carvalho, Vasco and Xavier Gabaix, "The Great Diversification and Its Undoing," *American Economic Review*, 2013, *103* (5), 1697–1727.

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.

Costinot, Arnaud and Andres Rodriguez-Clare, "Trade Theory with Numbers: Quantifying the Consequences of Globalization," in Gita Gopinath, Alhanan Helpman, and Kenneth Rogoff, eds., *Handbook of International Economics*, Vol. 4 2014. Chapter 4.

Dekle, Robert, Jonathan Eaton, and Samuel Kortum, "Unbalanced Trade," *American Economic Review*, May 2007, *97* (2), 351–355.

Eaton, Jonathan and Samuel Kortum, "Technology, Geography, and Trade," *Econometrica*, September 2002, *70* (5), 1741–1779.

Fan, Haichao, Edwin Lai, and Han Qi, "Global Gains from Reduction of Trade Costs," 2014.

Généreux, Pierre and Brent Langen, "The Derivation of Provincial (Inter-regional) Trade Flows: The Canadian Experience," *Statistics Canada Working Paper*, 2002.

Head, Keith and John Ries, "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade," *American Economic Review*, 2001, *91* (4), 858–876.

_ **and Thierry Mayer**, "Gravity Equations: Workhorse,Toolkit, and Cookbook," in Gita Gopinath, Alhanan Helpman, and Kenneth Rogoff, eds., *Handbook of International Economics*, Vol. 4 2014. Chapter 3.

Hillberry, Russell and David Hummels, "Intranational Home Bias: Some Explanations," *The Review of Economics and Statistics*, 2003, *85* (4), 1089–1092.

Hulten, Charles, "Growth Accounting with Intermediate Inputs," *Review of Economic Studies*, 1978, *45* (3), 511–18.

Ivison, John, "Harper government aims for deal to end provincial trade barriers," *National Post*, 29 May 2014.

Jones, Charles, "Misallocation, Economic Growth, and Input-Output Economics," in "Advances in Economics and Econometrics," Vol. 2, Cambridge University Press, 2013.

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," *Economic Inquiry*, 2013, *51* (1), 101–121.

Poncet, Sandra, "A Fragmented China: Measure and Determinants of Chinese Domestic Market Disintegration," *Review of International Economics*, 2005, *13* (3), 409–430.

Redding, Stephen J., "Goods Trade, Factor Mobility and Welfare," *NBER Working Paper 18008*, 2012.

Tombe, Trevor and Jennifer Winter, "What's Inside Counts: Migration, Taxes, and the Internal Gains from Trade," *University of Calgary Working Paper, 2013-28*, 2014.

Waugh, Michael E., "International Trade and Income Differences," *American Economic Review*, 2010, *100*, 2093–2124.

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*, 2012, *86*, 158–166.

Appendix A: Data Sources

Table 7 outlines the data sets used in our analysis. The internal trade data are obtained from CANSIM Table 386-0003. It contains provincial input-output tables pertinent to international and inter-provincial trade flows (inter-provincial and international exports and imports), as well as total supply and demand by province and commodity. As is unfortunately typical for Statistics Canada data, there are frequent revisions to the data that complicate time-series analysis. We use the most recent revision of the data (version 3, in CANSIM 386-0003), available for 2009 and 2010. We use the 2010 data, though none of our results are particular to that year.

Table 7: Data Sources

Source	Data
CANSIM 386-0003	Internal Trade Data
CANSIM 281-0024	Employment Data
CANSIM 384-0037	GDP Data
CANSIM 326-0015	Spatial Price Data
OECD-STAN	Input-Output Relationships

We map commodities to industries to match the OECD industry classification; details in the text. Secondly, annual employment data for each province are extracted from CANSIM Table 281-0024. Next, we obtain GDP data from CANSIM Table 384-0037, which reports gross domestic product, income-based by province and territory. Our spatial price data come from CANSIM Table 326-0015. The data encompasses inter-city indexes of price differentials of consumer goods and services such as food, shelter, household operations and so on. Toronto and Ottawa are separately reported in this data, so for Ontario's price we average the two cities. We display the relevant provincial data in Table 8.

Table 8: Provincial Data (2010)

Province	Abbreviation	GDP ($M)	Spatial Price Level	Real GDP Share ω_n
Alberta	AB	270,100	99	0.17
British Columbia	BC	205,996	103	0.12
Manitoba	MB	52,896	93	0.03
New Brunswick	NB	30,082	94	0.02
Newfoundland	NL	29,063	95	0.02
Nova Scotia	NS	37,073	99	0.02
Ontario	ON	629,500	105	0.36
Prince Edward Island	PE	5,202	93	0.00
Quebec	QC	329,670	95	0.21
Saskatchewan	SK	63,379	94	0.04

Lists the initial share of aggregate real GDP for each province ω_n – necessary to calculate counterfactual aggregate welfare. GDP and spatial price data are from 384-0037 and 326-0015, respectively.

Table 9: Industry Data from OECD-STAN

Industry	ISIC Rev. 3 Codes	Value-Added Share, ϕ^j	Final Goods Share, β^j	Input-Output Mult., μ^j	Trade Elasticity, θ^j
Agriculture, Mining	01-14	0.63	0.014	0.128	11.92
Food, Textiles	15-19	0.33	0.050	0.089	4.56
Wood	20	0.35	0.001	0.014	10.83
Paper	21-22	0.43	0.009	0.044	9.07
Chemicals, Rubber	23-25	0.21	0.027	0.120	19.16
Metals	26-28	0.34	0.005	0.090	5.02
Equipment, Vehicles	29-35	0.26	0.086	0.197	6.19
Manufacturing, n.e.c.	36-37	0.45	0.015	0.023	5.00
Utilities	40-41	0.73	0.013	0.033	5.00
Construction	45	0.40	0.133	0.154	5.00
Wholesale and Retail	50-52	0.61	0.110	0.185	5.00
Hotels and Restaurants	55	0.49	0.037	0.048	5.00
Transport	60-63	0.50	0.017	0.060	5.00
Communication	64	0.59	0.001	0.009	5.00
Finance	65-67	0.55	0.058	0.135	5.00
Real Estate	70-71	0.78	0.114	0.147	5.00
Software	72	0.57	0.006	0.035	5.00
Other Business Services	73-74	0.66	0.005	0.072	5.00
Public Admin.	75	0.51	0.140	0.154	5.00
Education	80	0.79	0.057	0.061	5.00
Health and Social	85	0.71	0.048	0.071	5.00
Other Services	90-93	0.61	0.057	0.095	5.00

Industry data from the OECD Structural Analysis Database. The Input-Output Multiplier μ^j is the j^{th} element of $(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{\beta}$, where $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ is the Leontief Inverse Matrix and $\boldsymbol{\beta}$ if the vector of final goods shares β^j. The trade elasticity is from the Caliendo and Parro (2015) estimates, averaged up to a slightly higher level of aggregation. Sectors 40 and above have elasticities of 5, consistent with Costinot and Rodriguez-Clare (2014).

Finally, our input-output industry data come from OECD-STAN structural analysis database. In addition to the input-output relationships between industries, the data also contains output, labour compensation, investment and international trade on an annual level. We aggregate all industries to the 22 industries listed in Table 9, along with relevant summary statistics for each industry. This level of aggregation is the finest possible, conditional on every province-sector pair have strictly positive levels of production and home-shares π^j_{nn}. This ensure a well defined solution to gains from trade using proposition 2.

We list the OECD input-output shares in Table 10. Each row is an industry purchasing inputs produced by another (column) industry, values will therefore sum to one across columns. For example, the wood products sector (sector 20) allocates 43% of its total intermediate inputs spending to primary sectors (such as forestry, within sector 01-14). Any shock to forestry, or any difficulties in accessing goods from that sector, will affect the wood products sector.

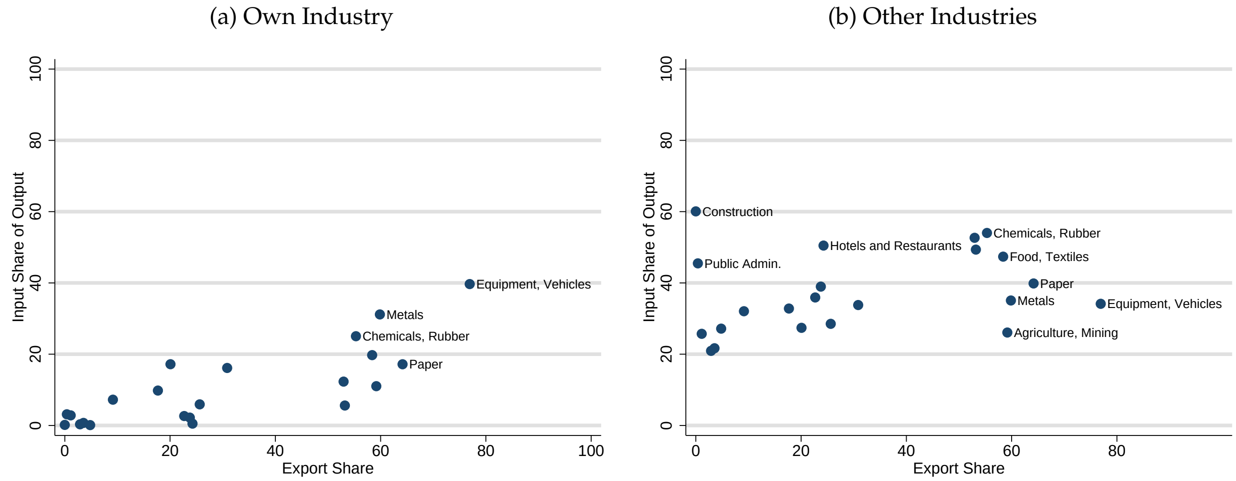
Are input-output linkages and trade related? In short, yes: industries that trade a lot also use inputs more intensively. We illustrate this in two ways. First, consider each industry's total inputs purchased by producers within the same industry (such as agricultural inputs used by agricultural producers). Panel (a) of Figure 4 plots this share for each industry against the industry's export intensity. There is a clear positive relationship; industries that purchase a lot of inputs are also

Table 10: Input-Output Shares γ^{jk} from OECD-STAN

	Producer Code																				
Buyer Code	01-14	15-19	20	21-22	23-25	26-28	29-35	36-37	40-41	45	50-52	55	60-63	64	65-67	70-71	72	73-74	75	80	85
01-14	0.297	0.059	0.002	0.014	0.119	0.035	0.072	0.002	0.034	0.023	0.096	0.006	0.041	0.001	0.092	0.015	0.028	0.043	0.007	0.001	0.001
15-19	0.326	0.294	0.001	0.050	0.067	0.025	0.013	0.003	0.014	0.002	0.066	0.003	0.036	0.002	0.026	0.009	0.010	0.034	0.005	0.000	0.001
20	0.429	0.003	0.189	0.011	0.063	0.023	0.022	0.003	0.027	0.003	0.099	0.002	0.062	0.001	0.025	0.006	0.006	0.016	0.002	0.000	0.000
21-22	0.060	0.010	0.056	0.301	0.094	0.014	0.028	0.002	0.060	0.007	0.082	0.012	0.071	0.009	0.044	0.022	0.030	0.045	0.008	0.002	0.001
23-25	0.446	0.009	0.002	0.016	0.317	0.013	0.013	0.002	0.022	0.003	0.045	0.003	0.031	0.001	0.020	0.006	0.011	0.024	0.005	0.000	0.001
26-28	0.189	0.003	0.003	0.011	0.046	0.471	0.034	0.005	0.036	0.007	0.081	0.003	0.037	0.001	0.026	0.007	0.006	0.021	0.004	0.000	0.000
29-35	0.005	0.005	0.002	0.010	0.058	0.169	0.538	0.003	0.007	0.002	0.063	0.004	0.022	0.001	0.020	0.012	0.017	0.049	0.003	0.001	0.001
36-37	0.048	0.062	0.114	0.044	0.132	0.151	0.036	0.102	0.015	0.002	0.139	0.006	0.025	0.005	0.031	0.018	0.016	0.029	0.005	0.001	0.000
40-41	0.379	0.005	0.001	0.032	0.074	0.017	0.066	0.002	0.004	0.103	0.040	0.007	0.042	0.004	0.077	0.007	0.045	0.040	0.037	0.001	0.001
45	0.097	0.013	0.075	0.010	0.105	0.237	0.091	0.022	0.002	0.003	0.112	0.003	0.030	0.002	0.037	0.018	0.016	0.109	0.007	0.002	0.000
50-52	0.020	0.017	0.003	0.055	0.066	0.010	0.020	0.005	0.031	0.010	0.069	0.034	0.061	0.034	0.181	0.088	0.052	0.137	0.021	0.008	0.003
55	0.042	0.381	0.001	0.032	0.021	0.006	0.010	0.004	0.027	0.010	0.113	0.010	0.019	0.002	0.095	0.092	0.018	0.058	0.014	0.004	0.001
60-63	0.013	0.005	0.001	0.012	0.207	0.010	0.053	0.001	0.013	0.034	0.083	0.020	0.323	0.005	0.072	0.046	0.010	0.036	0.016	0.001	0.001
64	0.025	0.005	0.002	0.040	0.075	0.009	0.024	0.003	0.006	0.006	0.142	0.010	0.295	0.054	0.078	0.064	0.043	0.076	0.008	0.003	0.001
65-67	0.010	0.005	0.001	0.051	0.022	0.004	0.013	0.002	0.012	0.008	0.049	0.030	0.031	0.023	0.386	0.054	0.076	0.116	0.015	0.005	0.003
70-71	0.036	0.004	0.001	0.016	0.024	0.006	0.017	0.002	0.046	0.274	0.044	0.010	0.018	0.012	0.290	0.032	0.015	0.102	0.018	0.001	0.001
72	0.009	0.011	0.002	0.076	0.061	0.015	0.051	0.004	0.006	0.005	0.077	0.025	0.038	0.016	0.058	0.081	0.230	0.136	0.013	0.011	0.002
73-74	0.008	0.009	0.002	0.061	0.068	0.019	0.059	0.005	0.010	0.007	0.097	0.030	0.037	0.021	0.079	0.116	0.098	0.172	0.017	0.006	0.002
75	0.016	0.011	0.001	0.026	0.082	0.011	0.041	0.009	0.021	0.042	0.081	0.015	0.031	0.008	0.025	0.039	0.040	0.079	0.065	0.020	0.271
80	0.045	0.014	0.001	0.129	0.062	0.012	0.043	0.007	0.073	0.080	0.087	0.027	0.128	0.011	0.018	0.042	0.034	0.083	0.024	0.016	0.002
85	0.016	0.032	0.001	0.040	0.113	0.017	0.075	0.083	0.038	0.021	0.126	0.031	0.018	0.011	0.045	0.063	0.016	0.057	0.016	0.007	0.100
90-93	0.012	0.019	0.001	0.079	0.061	0.012	0.086	0.014	0.028	0.015	0.125	0.020	0.027	0.015	0.069	0.089	0.041	0.074	0.023	0.003	0.002

Intermediate input shares by producing and purchasing industry code from the OECD Structural Analysis Database.. Corresponds to parameter γ^{jk} for row-j and column-k. Values sum to one across all columns for each row.

Figure 4: Export Shares and Intermediate Input Use, by Industry



Note: These scatter plots show the spending on intermediate inputs (as a share of output) against the share of output exported. Panel (a) shows each industry's inputs from their own industry (i.e. agricultural inputs used by agricultural producers). Panel (b) shows each industry's inputs from other industries (i.e. machinery inputs used by agricultural producers).

more export oriented. Second, consider each industry's total inputs purchased by producers from other industries (such as equipment inputs used by agricultural producers). Panel (b) displays those shares against export intensity, where the same pattern emerges.

Appendix B: Supplementary Material

How Sensitive is Welfare to Trade Cost Changes

In Table 5, we saw that Canada's welfare increases by 3.6% following a 10% reduction in τ_{ni}^{j} between provinces. For a 10% reduction in international trade costs, welfare increases by 2.9%. Following this reduction, we find internal trade volumes increase by over 80% and international trade volumes decline 8.5%. Instead, if we reduce τ_{ni}^{j} such that internal volumes grow by 10% (which involves $\hat{\tau}_{ni}^{j} = 0.985$), we find aggregate gains of 0.39% and international trade volumes decline 1%.

Gains differ across provinces. Provinces that initially have a low share of spending allocated to domestic producers (low π_{nn}^{j}) see the largest gains. Manitoba's initial average home-share across industries is 0.60 while Ontario's is 0.71. With lower home-share, a province's expenditures are allocated more to imported goods, so decreases in trade costs disproportionately benefit them. These regions are also relatively poorer, so regional income differences decline as τ_{ni}^{j} declines – by 2.3%, if measured by variance in (log) real GDP per worker across provinces. While these experiments do not correspond to specific policy experiments, they do serve to cleanly highlight that gains from lower trade costs are potentially quite large.

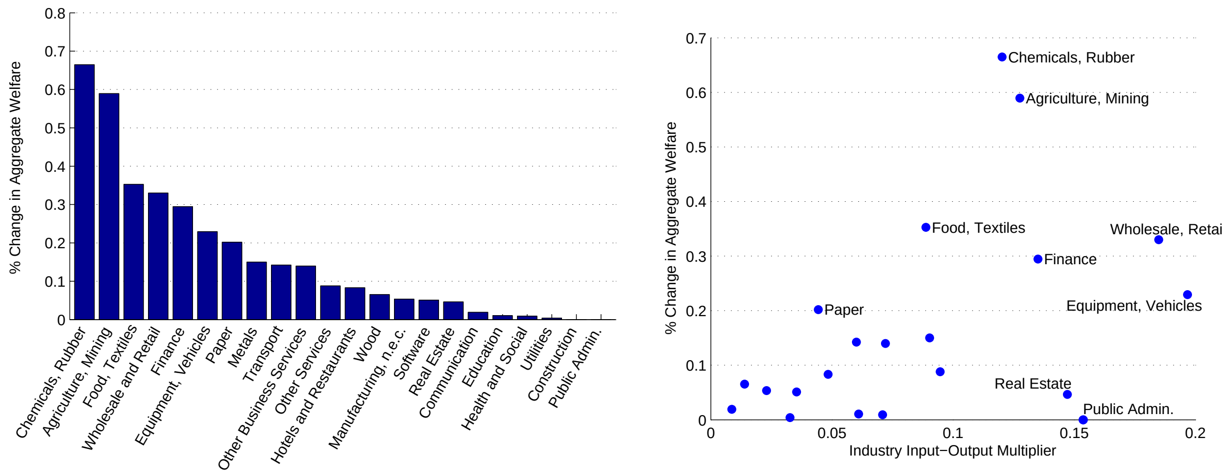
How sensitive is aggregate welfare to τ_{ni}^{j} in each industry? In the main text, we simulated lower measured trade costs in each industry. Here, we simulate changing τ_{ni}^{j} by 10% ($\hat{\tau}_{ni}^{j} = 0.9$) to identify the elasticity of aggregate welfare with respect to τ_{ni}^{j} in each industry. Unlike the main text, this does not correspond to any particular policy experiment. It serves to illustrate the behaviour of the model and reinforce the result that highly interconnected industries matter the most. We display the results in Figure 5.

There are large differences across industries in the effect of a 10% reduction in their τ_{ni}^{j} on aggregate welfare. The chemicals, rubber sector (which included refined petroleum products) increases aggregate national welfare by nearly 0.7% for a 10% reduction in τ_{ni}^{j}. Welfare is nearly as sensitive to τ_{ni}^{j} in agriculture and mining. Gains between 0.2-0.3% are had by reducing τ_{ni}^{j} in food, textiles, wholesale and retail, finance, and equipment and vehicles. These are all highly interconnected sectors, as well saw earlier. Trade costs facing those sectors will have a disproportionately negative aggregate effect. To see this, we plot the gains against each sectors input-output multiplier – it displays a clear positive relationship

Figure 5: Sensitivity of Welfare to τ^j_{ni}, by Industry

(a) Effect of 10% Lower τ^j_{ni}

(b) Welfare Gains vs. Input-Output Multipliers



Note: Displays the sensitivity of aggregate welfare to τ^j_{ni} in each industry by simulating $\hat{\tau}^j_{ni} = 0.9$. Panel (a) reports the aggregate welfare change, in decreasing order. Panel (b) plots these gains against each industry's input-output multipliers $(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{\beta}$.

Trade Cost Asymmetries and Sectoral Gravity Estimates

In section 2.3 of the paper, we discussed two additional trade cost measures: trade cost asymmetries and trade costs unrelated to geographic distance. Here, we provide details behind the estimation of both.

Following Waugh (2010), it is straightforward to show that in the models for which equation 1 holds, trade flows from i to n normalized by n's purchases from itself (π^j_{ni}/π^j_{nn}) depend only region-specific factors S^j_n and S^j_i (say, wages and productivity) and trade costs τ^j_{ni}.[9] Specifically,

$$ln(\pi^j_{ni}/\pi^j_{nn}) \quad = \quad -S^j_n + S^j_i - \theta^j ln(t^j_i) - \theta^j ln(t^j_{ni}).$$

To estimate this expression, researchers normally use proxies for symmetric trade costs t^j_{ni}, such as geographic distance. Importer fixed effects capture $-S^j_n$ and exporter fixed effects capture $S^j_i - \theta^j ln(t^j_i)$; adding the two fixed effects identifies t^j_i up to the trade elasticity θ^j. Specifically, estimate

$$ln\left(\frac{\pi^j_{ni}}{\pi^j_{nn}}\right) = \gamma^j ln(\bar{d}_{ni}) + \iota^j_n + \eta^j_i + \epsilon^j_{ni},$$

where γ^j is the distance-elasticities of trade in sector j. Our measure of distance $\bar{d}_{ni} = d_{ni}/\sqrt{d_{nn}d_{ii}}$ is the population-weight distance d_{ni} between province n and i, relative to the average within-province distances for n and i. City population and location data is available through the Global

[9]See Head and Mayer (2014) for further details and a review of the relevant literature.

Table 11: Results from Simple Industry-Level Gravity Regressions

Industry	Distance-Elasticity of Costs		Distance-Elasticity of Flows	
	$\hat{\delta}^j$	$s.e.\left(\hat{\delta}^j\right)$	$\hat{\gamma}^j$	$s.e.\left(\hat{\gamma}^j\right)$
Agriculture, Mining	0.17	0.01	-2.03	0.17
Food, Textiles	0.20	0.02	-0.92	0.11
Wood	0.10	0.01	-1.01	0.13
Paper	0.12	0.01	-1.12	0.12
Chemicals, Rubber	0.06	0.00	-1.09	0.10
Metals	0.21	0.02	-1.04	0.11
Equipment, Vehicles	0.15	0.01	-0.91	0.11
Manufacturing, n.e.c.	0.19	0.02	-0.97	0.10
Utilities	–	–	–	–
Construction	–	–	–	–
Wholesale and Retail	0.29	0.02	-1.49	0.11
Hotels and Restaurants	0.22	0.01	-1.11	0.08
Transport	0.22	0.01	-1.11	0.08
Communication	0.08	0.01	-0.41	0.04
Finance	0.16	0.01	-0.81	0.08
Real Estate	0.34	0.02	-1.72	0.11
Software	0.21	0.03	-1.10	0.16
Other Business Services	0.25	0.02	-1.23	0.11
Public Admin.	–	–	–	–
Education	0.24	0.02	-1.18	0.08
Health and Social	0.37	0.02	-1.88	0.14
Other Services	0.24	0.02	-1.20	0.10
Average	0.20	0.01	-1.18	0.11

Displays regressions results of industry-level gravity regressions of Head-Ries trade costs and (normalized) trade flows on a measure of bilateral distance between provinces of Canada.

Rural-Urban Mapping Project (version 1).[10] We estimate this for trading partners within Canada only and display the results in the last two columns of Table 11. The distance-elasticity of trade flows γ^j varies across sectors, but is typically close to the standard -1. The important estimates for our purposes are the exporter-specific costs t_i^j. We infer these from $ln(t_i^j) = -(\iota_i^j + \eta_i^j)/\theta^j$ and report their average values in Table 4.

Our second approach to isolate more policy-relevant costs also uses geographic distance. If trade costs are $\tau_{ni} = t_{ni}t_i$ then from equation 1 it is easy to show $\bar{\tau}_{ni}^j = \bar{t}_{ni}^j(t_i^j t_n^j)^{1/2}$, where $\bar{t}_{ni}^j = (t_{ni}^j t_{in}^j / \tau_{nn}^j \tau_{ii}^j)^{1/2}$. As before, we proxy the average symmetric relative trade costs $\bar{t}_{ni}^j$ with geographic distance $\bar{d}_{ni}$, which as defined above is relative to within-province distances. To purge $\bar{\tau}_{ni}^j$ of variation related to geographic distance, estimate

$$ln(\bar{\tau}_{ni}^j) = \delta^j ln(\bar{d}_{ni}) + \iota_n^j + \eta_i^j + \epsilon_{ni}^j.$$

We report the results of this regression for each industry in Table 11.

[10]The results are similar if we use the classic distance-between-capital-cities measure.

Appendix C: Proofs of Propositions

Proof of Proposition 1: Subtract imports from exports for a trade surplus $S_n^j = \sum_{i \neq n} \pi_{in}^j X_i^j - \sum_{i \neq n} \pi_{ni}^j X_n^j$, which need not equal zero. Since $\sum_{i \neq n} \pi_{ni}^j = 1 - \pi_{nn}^j$, and given our expression for revenue from equation 9, $R_n^j = X_n^j + S_n^j$. The aggregate trade surplus in region n is then $\sum_{j=1}^J S_n^j = \sum_{j=1}^J \left(R_n^j - X_n^j \right)$. Summing expenditures over sectors from equation 11, and using total income from equation 10, we have $\sum_{j=1}^J X_n^j = I_n + \sum_{k=1}^J (1-\phi^k) R_n^k = \sum_{k=1}^J R_n^k$ and therefore $\sum_{j=1}^J S_n^j = 0$. ■

Proof of Proposition 2: From equations 6, 7, and 8,

$$\frac{\hat{w}_n}{\hat{P}_n^j} = \hat{\pi}_{nn}^{j \; -\frac{1}{\phi^j \theta^j}} \left[\frac{\Pi_{k=1}^J \hat{P}_n^{k \; \gamma^{jk}}}{\hat{P}_n^j} \right]^{-\frac{1-\phi^j}{\phi^j}},$$

which is identical to Caliendo and Parro (2015). We proceed further; first, with a simple manipulation:

$$\begin{aligned} log\left(\frac{\hat{w}_n}{\hat{P}_n^j}\right) &= -\frac{1}{\phi^j \theta^j} log\left(\hat{\pi}_{nn}^j\right) - \sum_{k=1}^J \frac{\gamma^{jk}\left(1-\phi^j\right)}{\phi^j} log\left(\hat{P}_n^k\right) + \frac{\left(1-\phi^j\right)}{\phi^j} log\left(\hat{P}_n^j\right), \\ \Rightarrow \; log\left(\frac{\hat{w}_n}{\hat{P}_n^j}\right) &= -\frac{1}{\theta^j} log\left(\hat{\pi}_{nn}^j\right) + \sum_{k=1}^J \gamma^{jk}\left(1-\phi^j\right) log\left(\hat{w}_n / \hat{P}_n^k\right). \end{aligned}$$

Next, note that the coefficients on $log\left(\hat{w}_n / \hat{P}_n^k\right)$ in the summation above are just elements of the standard Direct Requirements Matrix $\mathbf{A}$ from an Input-Output Table. Staking the above set of equations, defining $\tilde{\mathbf{G}}$ as the $J \times N$ matrix of real wage changes with elements $log\left(\hat{w}_n / \hat{P}_n^j\right)$ and $\mathbf{G}$ as the $J \times N$ matrix with elements $-log\left(\hat{\pi}_{nn}^j\right) / \theta^j$, yields

$$\begin{aligned} \tilde{\mathbf{G}} &= \mathbf{G} + \mathbf{A}'\tilde{\mathbf{G}}, \\ \Rightarrow \tilde{\mathbf{G}} &= (\mathbf{I} - \mathbf{A}')^{-1}\mathbf{G}. \end{aligned}$$

If trade balances, we can write welfare gains in a similar way. Specifically, if $S_n = 0$ for all regions then $\hat{I}_n = \hat{w}_n$ and, from proposition 3, we have

$$\hat{U}_n = \prod_{j=1}^J \left(\hat{w}_n / \hat{P}_n^j\right)^{\beta^j}.$$

Taking logs and staking the result into an $N \times 1$ vector of (log) welfare changes yields

$$\hat{\mathbf{U}} = \mathbf{G}'(\mathbf{I} - \mathbf{A})^{-1}\boldsymbol{\beta},$$

where $\boldsymbol{\beta}$ is the $J \times 1$ vector of final goods shares β^j. ■

Proof of Proposition 3: With household utility given by equation 3, the indirect utility is simply

$$U_n = \prod_{j=1}^{J} \left(\frac{\beta^j I_n}{P_n^j} \right)^{\beta^j}, \tag{16}$$

where $P_n = \prod_{j=1}^{J} {P_n^j}^{\beta^j}$. Welfare changes are therefore

$$\hat{U}_n = \hat{I}_n / \hat{P}_n,$$

The aggregate national welfare is the population weighted average welfare. That is, $U = \sum_{n=1}^{N} \lambda_n U_n$. So,

$$\begin{aligned}
\hat{U} &= \frac{\sum_{n=1}^{N} \lambda_n U_n'}{\sum_{n=1}^{N} \lambda_n U_n}, \\
&= \frac{\sum_{n=1}^{N} \lambda_n \hat{U}_n U_n}{\sum_{n=1}^{N} \lambda_n U_n}, \\
&= \sum_{n=1}^{N} \hat{U}_n \frac{\lambda_n \mu_n}{\sum_{n=1}^{N} \lambda_n \mu_n}, \\
&= \sum_{n=1}^{N} \hat{U}_n \omega_n,
\end{aligned}$$

where we use equation 16 and define $\mu_n = I_n / P_n$ as initial real income, which we take from data. ■

Appendix D: Alternative Modeling Assumptions

We explore a few modifications to the model. First, we allow for labour mobility between regions. Second, we explore the results when provincial trade is unbalanced. We simulate and compare the results primarily with the τ-elasticity of aggregate welfare exercises, though none of the other quantitative exercises depend on these modeling assumptions.

Labour Mobility

To simulate labour mobility, we must slightly modify the model following Redding (2012) and Caliendo et al. (2014). First, the production technology changes to

$$y_n^j(\omega) = \varphi_n^j(\omega) \left[l_n^j(\omega)^\alpha h_n^j(\omega)^{1-\alpha} \right]^{\phi^j} \left[\prod_{k=1}^{J} m_n^{jk}(\omega)^{\gamma^{jk}} \right]^{1-\phi^j},$$

where $h_n^j(\omega)$ are immobile factors (henceforth, land) and α is the value-added share of mobile inputs. In our data, labour's share is 0.54, with most industries clustered fairly close to one another. To ease the derivations to follow, we assume all sectors share the same value-added share for mobile inputs. We present results for a broad range of values for α.

The cost of an input bundle now depends on the price of land, denoted r_n. So, the counterfactual relative change in input costs for industry j in region n is

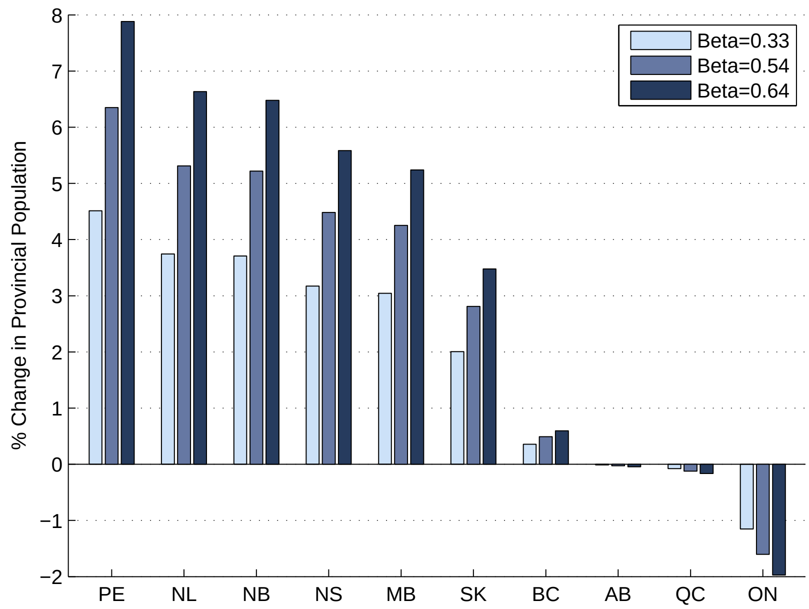
$$\hat{c}_n^j = \left[\hat{w}_n^\alpha \hat{r}_n^{1-\alpha} \right]^{\phi^j} \left[\prod_{k=1}^{J} \left(\hat{P}_n^k \right)^{\gamma^{jk}} \right]^{1-\phi^j}.$$

What determines the change in land prices? Given revenue of sector j as R_n^j, total spending on land is $(1-\alpha)\phi^j R_n^j$. Similarly, total spending on labour is $\alpha\phi^j R_n^j = w_n L_n^j$. So, total land spending is $\frac{1-\alpha}{\alpha} w_n L_n^j$. This holds in all sectors. So, aggregate spending on land for the whole economy is $\frac{1-\alpha}{\alpha} \sum_{j=1}^{J} w_n L_n^j = \frac{1-\alpha}{\alpha} w_n L_n$. The total supply of land is H. So, the price of land that clears the market is the ratio of total spending to total land supply. This implies $\hat{r}_n = \hat{w}_n \hat{L}_n$.

Finally, since individual agents may freely migrate between provinces, household utility equalizes across regions. Any equilibrium will therefore be such that $\hat{U}_n = \hat{U}_{n'}$ for all regions $n \neq N+1$ and $n' \neq N+1$. That is, changes in real income are identical across provinces in Canada but not necessarily between any province and the rest of the world. Importantly, this does not imply that there are no level differences in real income between provinces in the initial equilibrium. Though it does imply the ratio of two province's real incomes is unchanged between the initial and counterfactual equilibria.

With these adjustments in place, we simulate the model response to a 10% reduction in τ_{ni}^j, with and without complete input-output linkages. The change in the spatial distribution of primary factors (more simply, changes in provincial population) is depicted in Figure 6. Overall, *lower*

Figure 6: Reallocation of Primary Factors from 10% Lower Internal Trade Costs



Note: Displays the effect of reducing all internal trade costs by 10% on each province's stock of primary factors. The complete set of input-output relationships are present. Overall, lower internal trade costs shifts resources towards relatively lower income regions. The results are nearly identical when input-output relationships are excluded.

trade costs induce migration *away* from relatively well-off regions – which implies internal trade costs cause more people to live in rich regions. As mobile factors (labour) become more important in the production technology (higher α), the migration response increases. With a high $\alpha = 2/3$, Ontario loses nearly 2% while Atlantic provinces gain between 5-8%. When $\alpha = 1/3$, Ontario loses about 1% while Atlantic provinces gain between 3-4%.

How do input-output linkages influence outcomes when labour is mobile? Unlike productivity and welfare changes, these linkages have little effect. This should not be surprising, as what matters for migration decisions are *relative* changes in welfare across regions and Input-Output Multiplier differs only by sector, not by region. Aggregate welfare responses to lower internal trade costs are similar to our baseline simulations of a 10% lower internal trade cost. When input-output linkages are present, aggregate welfare increases by roughly 3.2% (regardless of α). Without input-output linkages, welfare increases by only 2%. We therefore conclude our main results are robust to factor mobility across provinces.

Exogenous Aggregate Trade Imbalances

Our results do not depend on the balanced trade assumption we imposed, although the clean expressions derived in proposition 2 require it. This assumption, however, is at odds with data. Indeed, in Table 12 we report surpluses as high as 4% of GDP for Ontario or deficits as high as 22% of GDP for PEI. We are not interested in the ultimate cause of trade imbalances. Instead, this

Table 12: Provincial Data (2010)

Province	Employment (000s)	GDP ($M)	Trade Surplus (% of GDP)	Spatial Price (All-Items)	Real GDP/Worker
AB	1,760	270,100	2.3%	99	154,985
BC	1,895	205,996	-4.7%	103	105,527
MB	558	52,896	-10.2%	93	101,989
NB	321	30,082	-11.8%	94	99,823
NL	200	29,063	-1.8%	95	153,148
NS	406	37,073	-12.0%	99	92,176
ON	5,643	629,500	4.2%	105	106,236
PE	64	5,202	-22.2%	93	86,758
QC	3,394	329,670	0.7%	95	102,258
SK	442	63,379	-16.4%	94	152,717

Relevant provincial data to initialize the model simulations. Employment data are from CANSIM 281-0024, GDP from 384-0037, trade surplus from 386-0003, and spatial prices from 326-0015.

exercise ensures our results are not driven by the balanced trade assumption.

The model will change, becoming closer to Caliendo and Parro (2015). Denote an trade surpluses S_n sustained by exogenously imposed cash transfers out of region n. Regions that receive the transfers sustain a trade deficit (where $S_n < 0$). Across all regions of Canada, there is no imbalance and $\sum_{i=1}^{N-1} S_n$. We assume no international imbalance between Canada and the world, so $S_N = 0$. Equations 3 through 9 are unchanged. Equation 10 becomes $I_n + S_n = \sum_{j=1}^{J} \phi^j R_n^j$, where $S_n = \sum_{j=1}^{J} S_n^j$ is the aggregate surplus in region n, and therefore $\sum_{j=1}^{J} R_n^j = S_n + \sum_{j=1}^{J} X_n^j$. Holding the aggregate surplus S_n fixed in all counterfactuals, one can easily derive equilibrium relative changes as before. The only two changes are that S_n is added to the right-hand-side of equation **??** and $\hat{w}_n = (I_n' + S_n) \,/\, (I_n + S_n)$ instead of the $\hat{I}_n$ without imbalances. With these changes, we can repeat any of our counterfactual experiments.

Compared to our main results, the aggregate gains from internal trade are slight larger (but still round to 4.4%). The largest change for any province is for Saskatchewan, whose gains from internal trade are 8.4% instead of 7.1% in the balanced trade case. In our experiment where τ_{ni}^j declines by 10% in all sectors of Canada, aggregate gains are 3.14% in the unbalanced case compared to 3.2% in our main results, and there is no significant change for any province – all gains are within one percentage point of the balanced trade case. The only substantial change to the previously reported welfare gains are for Saskatchewan in two experiments, which gains 51% with unbalanced trade after eliminating trade cost asymmetries and gains 109% after eliminating all internal costs (compared to 71% and 138% reported earlier). Finally, our industry-specific experiments are also robust to trade imbalances – the ranking of industries by gains following a 10% trade cost reduction is identical and the magnitudes are similar. Our quantitative results are therefore not driven by balanced trade.