Fiscal Integration with Internal Trade: Quantifying the Effects of Equalizing Transfers†

Trevor Tombe
University of Calgary

Jennifer Winter
University of Calgary

This Version: October 2018

Abstract

Fiscal transfers between regions exist within many countries. Explicit transfers, such as Canada's equalization program, redistribute funds directly, and countless federal revenue and spending programs do so indirectly. And like capital flows between countries, such transfers interact with trade and affect the distribution of economic activity within and between provinces. Previous research has largely abstracted from trade considerations; we fill this gap. With the aid of a rich quantitative model and detailed data on within-country trade and financial flows, we uncover important effects of fiscal transfers on provincial income, internal trade flows, migration, and national GDP. The effects are large. Transfers lower Alberta's real income by over 8 per cent and its population by over 12 per cent, and increase PEI's real income by 30 per cent and its population by nearly 50 per cent. We further find transfers misallocate labour across provinces and lower Canada's real GDP by over 0.8 per cent — equivalent to nearly $19 billion per year today. Finally, fiscal transfers spread gains from trade across all regions, even if policy (like the New West Partnership) liberalizes trade only among some.

JEL Classification: F1, F4, H5, R1

Keywords: Fiscal integration; internal trade; gains from trade; misallocation; productivity

---

† Previous version circulated as "What's Inside Counts: Migration, Taxes, and the Internal Gains from Trade".

Tombe (Corresponding Author): Associate Professor, Department of Economics, University of Calgary, 2500 University Drive NW, Calgary, Alberta, T2N1N4. Email: `ttombe@ucalgary.ca`. Phone: 1-403-220-8068. Winter: Assistant Professor and Scientific Director of Energy and Environmental Policy, The School of Public Policy, University of Calgary. Email: `jwinter@ucalgary.ca`.
We greatly benefited from comments and suggestions made by anonymous referees and various conference participants at the SED Annual Meeting 2012, MidWest Macro 2012, CEA Annual Meeting 2012, AEA Annual Meeting 2015, and various seminar participants at Wilfrid Laurier University and the University of Calgary. We also gratefully acknowledge the financial support of the Social Science and Humanities Research Council (specifically, IG 435-2015-0151 and an Institutional Grant to Wilfrid Laurier University).

1 Introduction

Financial transfers between sub-national regions are ubiquitous. Explicit programs to equalize per capita incomes exist within many countries, including in Australia, Belgium, Canada, China, France, Germany, Switzerland, the United Kingdom, and others.[1] In the United States, while no explicit program exists, many federal revenue or spending programs respond to income (for example, Medicaid and unemployment insurance) and federal income taxes naturally raise more revenue per person from higher-income states. Though such transfers benefit certain regions, they can lower a country's overall level of economic activity. If workers migrate in response to fiscal benefits rather than more fundamental considerations like productivity, then labour will be misallocated and aggregate GDP may decline.[2] This is the subject of a large literature (Buchanan, 1950, 1952; Boadway and Flatters, 1982; Watson, 1986; Wilson, 2003; Albouy, 2012), but one that largely abstracts from trade. This matters: capital flows and trade imbalances between countries affect resource allocation, incomes and productivity, and there are similar effects within countries. With the aid of a rich quantitative model and detailed data on within-country trade and financial flows, we uncover important effects of fiscal transfers on trade flows, specialization patterns, and the gains from trade. In addition, we demonstrate that the effect of transfers on migration — the focus of much of the previous literature — is significantly amplified by trade and therefore increases the potentially negative effect of transfers on aggregate GDP and productivity.

The intuition behind the interaction between trade and fiscal transfers is as follows. Imagine a region in autarky, without any imports or exports. Financial transfers into this region are nothing more than "helicopter money" affecting nominal variables, not real. Incomes and prices rise proportionally and real incomes are left unchanged. For welfare gains to exist at all, prices must rise less than incomes, and openness to trade will deliver just that. The degree of trade openness will also matter as incomes and wages will respond differently to transfers depending on the level of trade costs. Consider a world of frictionless trade. If preferences are similar across regions, then consumers will allocate their spending in the same way (that is, to the lowest cost producers) regardless of where they live. Any redistribution of income will not affect demand for any region's output. As a result, wages and prices are left unaffected though the distribution of income and consumption will be. But in a world with costly trade, a net transfer into a region will differentially increase demand for locally produced goods relative to imports. This increases wages and prices, though wages respond more as the presence of imports dampens the price change. Thus, depending on the level of trade costs, transfers will affect incomes, wages, and prices in different ways, which will in turn affect migration and aggregate real GDP differently.

We build on this intuition with a rich model of trade and transfers and present the first quantitative estimates of the effects on real income (welfare), real wages, trade, and migration from

[1] For a comprehensive examination of fiscal transfer systems around the world, see Boadway and Shah (2007).

[2] In principle, transfers may offset other factors that motivate inefficient migration — such as resource rents accruing to a provincial government. In such a situation, transfers could (if they are well calibrated) improve efficiency and increase aggregate economic activity. But Canada's system of fiscal transfers appears poorly suited to that goal (Albouy, 2012).

federal fiscal transfers in Canada. Specifically, we augment a modern, quantitative trade model featuring multiple regions, multiple interconnected sectors, mobile labour across provinces, and an endogenous fiscal transfer regime. Our model is, at its core, an Eaton and Kortum (2002) trade model with multiple sectors linked through rich input-output relationships as in Caliendo and Parro (2015). Workers are mobile across regions, though not perfectly so. Following Tombe and Zhu (2018), workers differ in their taste for different regions and optimally choose where to live and work based on their tastes, migration costs, and real incomes. On top of this core, we introduce a fiscal transfer system. Instead of exogenous lump-sum transfers typical in the literature, we incorporate endogenous transfers through federal revenue and spending programs that respond to changes in provincial income levels. Essentially, transfers add to labour income in the model and both respond endogenously to policy shocks.

We fit the model to high-quality and detailed data on internal trade and fiscal redistribution between provinces in Canada. Canada provides an ideal setting to study fiscal integration and trade. Not only is high quality data on both readily available, but federally facilitated financial flows are large and strongly correlate with provincial income. Poor regions receive very large net inflows — on the order of 10-20 per cent of their GDP — and overall transfers are equivalent to roughly 1.9 per cent of Canada's GDP. Not all transfers are due to redistributive federal programs, but a significant portion are. We estimate that transfers that endogenously respond to provincial incomes — which we call "income-sensitive transfers" — are equivalent to 1.4 per cent of GDP. Canada's trade data is also uniquely detailed, and provides a full matrix of trade flows between provinces for multiple sectors. Properly calibrated, the model exactly matches observed trade flows and fiscal transfers. For trade costs, we rely on recent evidence from Albrecht and Tombe (2016), who provide a variety of internal trade cost estimates for multiple sectors and each of Canada's provinces. Internal trade costs are high, and have strong asymmetries: export costs are higher in poorer regions (as Waugh, 2010, found between countries). These asymmetries matter for the effects of fiscal integration.

With this model we perform a variety of counterfactual simulations. First, we quantify the effect of fiscal integration in Canada. We find substantial effects, with real income gains ranging between 15 to 30 per cent for lower-income Maritime[3] provinces and losses of 8 per cent for the highest-income province of Alberta. Migration responses are similarly large, with transfers increasing employment in the Maritime provinces by between 24 to 47 per cent, and decreasing employment in Alberta by over 12 per cent. Overall, we estimate 3.2 per cent of the population shifts away from relatively higher-income provinces of Alberta, Ontario, British Columbia and (to a lesser extent) Saskatchewan towards the other provinces. The aggregate effect on Canada's overall GDP from these transfers, and the resulting misallocation of labour, is a loss of 0.84 per cent — equivalent to nearly $19 billion annually today. This is significantly more costly than the estimated aggregate loss of 0.3 per cent in an alternative model without trade responses, or the 0.4 per cent loss estimated by Albouy (2012). In short, trade amplifies the misallocation of labour

[3]The Maritime provinces are Nova Scotia, New Brunswick and Prince Edward Island.

across provinces from fiscal transfers.

There are important implications for the spatial distribution of economic activity within provinces. The inter-sectoral linkages in the model matter a great deal, qualitatively and quantitatively. As some sectors supply inputs to others, shocks to one part of the economy cascade through, and are multiplied by, these linkages. In addition, fiscal transfers will have differential effects across sectors. A region receiving transfers will see an expansion of sectors close to final consumers (the downstream sectors) relative to input suppliers (the upstream sectors). The source of this effect is intuitive. Financial inflows raise a region's households' income, increasing their demand for final goods. Wages also increase in these regions, lowering the competitiveness of upstream sectors that do not see the same increased demand as downstream sectors do. The opposite occurs in regions with financial outflows. This intuition is identical to Acemoglu et al. (2016), who show demand shocks propagate upstream. Measuring upstreamness as in Antras et al. (2012) – that is, as the average number of production stages producers are away from consumers – we find that over 10 per cent of the variation in observed upstreamness across provinces can be accounted for by Canada's system of fiscal integration.

Beyond quantifying the effect of transfers, our analysis also reveals that fiscal transfers change the way in which trade and trade costs affect economic activity. First, moving to autarky not only eliminates the gains from trade, but also completely eliminates any effect that fiscal transfers have on real income or real wages. Without trade, there can be no trade imbalance and therefore no effect of transfers on real income. In this sense, trade and fiscal integration complement each other. Second, different types of trade cost changes lead to different effects on provinces. Federal government income taxes are levied on nominal, not real, incomes. Changes in households' income has tax implications while changes in prices do not; the source of the gains from trade therefore matters. Typically, if import costs fall, then so do wages and prices (though prices fall more). If fiscal transfers shift income towards lower-wage areas, then a region with falling import costs will gain from trade *and* from increased transfers. On the other hand, if export costs fall, then wages and prices rise (though wages rise more). In this case, a region with falling export costs will gain from trade *but lose* from reduced transfers. We show these effects are quantitatively important, with large differences between regions and between sectors. We find that when internal asymmetries are eliminated, real income gains are far smaller than the real wage gains for poor regions — less than half as large as in a standard model.

Finally, transfers spread the gains from trade even if only a subset of provinces liberalize. Bilateral agreements to liberalize internal trade are a growing trend in Canada. BC, Alberta, and Saskatchewan established the New West Partnership Agreement, for example, which Manitoba recently joined. The Ontario-Quebec Trade and Cooperation Agreement is similar. The international trade literature has conclusively established that bilateral deals can create trade diversion effects which can harm non-members. The same basic logic applies within a country, but in contrast, we find fiscal integration spreads gains to everyone. We show all regions experience gains when only certain provinces liberalize trade. Trade diversion effects still exist, and real wages (typically) fall in regions outside the agreement, but incomes in these regions increase as fiscal transfers more than compensate.

Our work contributes to a number of literatures. First, research investigating the magnitude and consequences of within-country trade costs is a growing area of research, as new data and methods become available (Allen and Arkolakis, 2014; Agnosteva et al., 2014; Atkin and Donaldson, 2015; Redding, 2016; Cosar and Fajgelbaum, 2016). While not directly related to the literature measuring the internal costs of trade, in the appendix we demonstrate that trade cost asymmetries are as important within countries as they are between countries. Following Waugh (2010), we combine trade data with spatial price data to show that poor regions typically face larger costs of exporting than rich regions. Our primary contribution to this literature is to highlight the quantitatively important interactions between internal trade and fiscal integration. The distribution of gains from trade and of national employment depend crucially on inter-regional fiscal transfers.

Second, our results that link fiscal transfers to the composition of economic activity within a province is related to those exploring financial transfers and the structure of trade across countries. Epifani and Crino (2014), for example, find trade surpluses may increase or decrease labour demand in skill-intensive sectors, depending on whether a country is skill abundant or not. Epifani and Gancia (2017) find a strong and robust link between trade balances and industrial composition, empirically and theoretically, and show trade surpluses affect different sectors differently, shifting labour towards tradable sectors. In our analysis, all sectors are tradable and we show different transfers have different effects across sectors that depend on each sector's location along the supply chain. In particular, negative transfers create a trade surplus and shifts activity towards *upstream* sectors in our framework. The transfers in our framework are also endogenous and depend on a region's relative income levels.

Most importantly, we contribute to a large literature investigating the efficiency consequences of potential spatial distortions from fiscal policy within countries. Most recently, Fajgelbaum et al. (2018) show variation in state taxes in the United States is an important source of spatial misallocation. They estimate U.S. aggregate welfare would increase between 0.6 to 1.2 per cent if state taxes were harmonized. Our analysis complements theirs by focusing on spatial differences in federal revenue and spending, rather than state-level policy, and we demonstrate similarly large aggregate implications. Prior research on federal transfers has long focused on worker migration (Buchanan, 1950; Boadway and Flatters, 1982; Watson, 1986; Albouy, 2012); we build on this by allowing for trade and production responses. This is novel and, as we demonstrate, important. Albouy (2012) is perhaps closest to our work. And while he estimates the migration and real income consequences of transfers, both in aggregate and for each province, we demonstrate internal trade responds to transfers and significantly amplifies the aggregate effect of transfers. In addition, this previous literature has explored the aggregate consequences of explicit inter-provincial transfer programs — especially equalization. We go beyond this and consider inter-provincial transfers from all federal revenue and spending programs.

2 Fiscal Integration and Trade Costs Within Canada

We begin our analysis by outlining key features of integration in Canada. We present measures of equalizing transfers between regions, and estimates of the internal trade costs faced by each region and sector. Canada provides a unique setting to jointly examine internal trade and fiscal integration. Not only does detailed trade data exist across provinces and sectors, but federal revenue and expenditures are reported by province. We can therefore precisely measure between-province financial transfers facilitated by the federal government. In this section, we present these data and relate fiscal transfers to provincial incomes and trade imbalances. We end the section with a brief review of existing internal trade cost estimates.

2.1 Fiscal Integration

How fiscally integrated are Canadian provinces? The federal government transfers funds between regions in many ways. Most prominently, through a specific system of equalization payments, the federal government transfers funds to poorer provincial governments according to a preset formula. The purpose, enshrined in the Constitution, is to "ensure that provincial governments have sufficient revenues to provide reasonably comparable levels of public services at reasonably comparable levels of taxation" (Subsection 36(2) of the *Constitution Act, 1982*). The transfers do not end there, however. Most programs that transfer fiscal resources across provinces are not explicitly designed to do so, unlike Canada's equalization program. We provide recent data on all federal spending and revenue, by province, as a share of each province's GDP in Table 1. We call a *net fiscal transfer* a situation where federal expenditures within a province exceed revenue raised from that province. For the relatively lower-income Maritime provinces, net transfers are sizable. Transfers to Prince Edward Island, Nova Scotia, and New Brunswick, for example, are equivalent to 20.6, 17, and 13.8 per cent of their GDP. Overall, the correlation between net transfers and real GDP per capita is -0.75. Given this strong negative relationship and the overall magnitude of transfers, they are effective at lowering regional income differences in Canada. The variance of log observed relative GDP per capita $ln(y_n)$, for example, is nearly half the variance of $ln(y_n(1-t_n))$, where t_n is the net transfer as a share of GDP.

These large transfers are neither due to the equalization program nor to other explicit transfer programs. Indeed, the two other major programs — the Canada Health Transfer and the Canada Social Transfer — are together nearly triple the size of equalization but are distributed on an equal per-capita basis across all provinces. Most inter-provincial transfers are the side-effect of countless federal programs. Regions with higher employment rates or with disproportionately more high-income households will tend to pay more federal personal income taxes. High-income regions also tend to have higher levels of consumer spending, and therefore pay more federal GST per capita than elsewhere. On the spending side, regions with greater employment and higher incomes will also see lower federal spending on employment insurance payments. And regions with a higher share of elderly individuals, such as in the lower-income Atlantic provinces, receive more Old Age

Table 1: Measuring Fiscal Transfers in Canada (2007-2016)

Province	*Dollars per Capita Relative to the National Average* Federal Expenditure	Federal Revenue	Net Transfers	GDP per Capita	Population Share (%)
BC	-619	246	-865	49,253	13.1
AB	-1,761	4,524	-6,285	78,785	11.2
SK	616	781	-165	66,512	3.1
MB	2,471	-894	3,365	46,766	3.6
ON	85	525	-440	50,631	38.7
QC	-987	-2,990	2,003	43,375	23.3
NB	4,518	-1,359	5,877	41,280	2.2
NS	6,070	-951	7,021	40,069	2.7
PE	6,358	-1,668	8,026	38,014	0.4
NL	5,046	1,539	3,507	59,414	1.5

Summarizes the magnitude and distribution of between-province transfers in Canada. Population data are from Statistics Canada data table 17-10-0005-01 and federal revenue and spending by province data are from table 36-10-0450-01. The data are averaged across the ten years from 2007 to 2016.

Security and Canada Pension Plan payments. In Table 1, we quantify transfers as the aggregate of all federal revenue and spending programs relative to the national average.[4]

Specifically, we measure per capita federal spending s_i and revenue r_i relative with the national average values $\bar{s}$ and $\bar{r}$ and define per capita implicit transfers for each province i as $t_i = (s_i - \bar{s}) - (r_i - \bar{r})$. Federal programs are a net inflow if $t_i > 0$ (either due to higher spending, lower revenue, or some combination of the two) and are a net outflow if $t_i < 0$. Across all provinces, the aggregate transfer is half the absolute value of $T_i = t_i \times P_i$, where P_i is the population of province i; that is, $T = \frac{1}{2}\sum_{i=1}^{N} |T_i|$. Overall, transfers through federal revenue and spending programs can be large. The implicit outflow from Alberta, for example, is roughly 8 per cent of GDP while the inflow to PEI is over 21 per cent. To decompose these implicit transfers by component, we also compare per capita values. In Alberta, for example, personal income tax payments averaged $5,786 per capita between 2007 and 2016, which is nearly $2,168 higher than the national average. Personal income taxes therefore account for one-third of the nearly $6,300 per person total net outflow from Alberta. Decomposing national transfers by source is more difficult, since (unlike Alberta) many provinces experience a net inflow due to some components but net outflows due to others. For instance, Ontario is the destination of significant federal spending, as it is the home of the capital city of Ottawa, but also pays disproportionately more in federal income taxes. The contribution of any particular revenue or spending program to aggregate transfers therefore depends on the values of other revenue or spending programs.[5] We therefore quantify the marginal contribution

[4]For a broader review of transfers and redistributive federal revenue and spending programs, see Tombe (2018).

[5]More formally, Jensen's inequality implies $\frac{1}{2}\sum_i |T_i| = \frac{1}{2}\sum_i |\sum_j T_i^j| \leq \frac{1}{2}\sum_i \sum_j |T_i^j|$ and holds with equality only if T_i^j are the same sign across all components j within each province i.

Table 2: Decomposing the Sources of Fiscal Transfers in Canada (2007-2016)

Component	Share of National GDP (%)	Share of Transfers (%)	Correlation with GDP/Capita
Personal Income Taxes	0.60	31.1	0.88
Equalization / Stabilization	0.44	22.7	-0.77
Corporate Income Taxes	0.20	10.2	0.94
CPP Net Contributions	0.15	8.0	0.80
Non-Defense Purchases	0.11	5.8	-0.68
EI Payments less Receipts	0.11	5.7	0.36
OAS Benefits	0.10	5.4	-0.66
GST and Excise Taxes	0.09	4.6	0.90
Defense Purchases	0.05	2.8	-0.42
Other Items	0.07	3.6	0.05

Decomposes the aggregate between-province transfers by component. Transfers here are defined as half the absolute value of deviations from average per-capita values. Column two displays the share of total transfers T accounted for by each component. See text for details. Column three reports the correlation between each component's implicit transfer across provinces ($t_i^j - \bar{t}^j$) with provincial GDP per capita.

of transfers T_i^j from component j to or from province i on total transfers $T = \frac{1}{2}\sum_i |T_i| = \frac{1}{2}\sum_i |\sum_j T_i^j|$ by adding each in sequence. We then average these marginal contributions across all 3.6 million (10!) possible orderings. We report the results in Table 2.

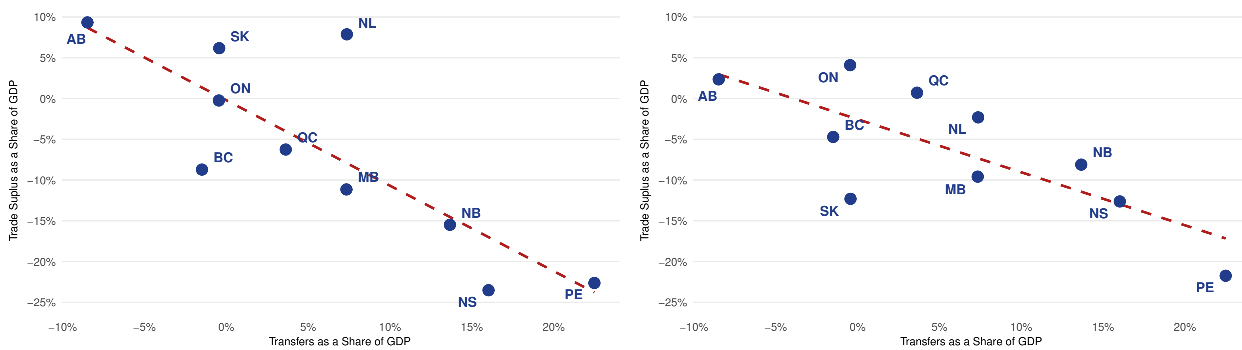
We find that between 2007 and 2016, federal revenue and spending redistributed just under 2 per cent of Canada's overall GDP. The bulk of these transfers are in components that are sensitive to a province's GDP per capita. Over 40 per cent of all transfers are due to personal and corporate income taxes. Add to those explicit transfer programs from the federal government, along with GST payments and net employment insurance (EI) contributions, and roughly three-quarters of transfers automatically respond to economic conditions. To show this more clearly, we report their correlation to GDP per capita in the last column of Table 2. All are intuitive. Higher income regions disproportionately contribute to federal revenue through higher personal and corporate income taxes, and greater EI and Canada Pension Plan (CPP) payments relative to their receipts. Government-to-government transfers are also negatively related to income – primarily due to the equalization program. To be sure, not all components may be related to a region's economic conditions. Defence expenditures per capita are particularly large in Nova Scotia, home of Canada's Atlantic fleet at CFB Halifax. It is clear that a large majority of inter-provincial transfers respond to underlying economic conditions in a province.

These transfers matter not only because they reallocate financial resources across governments, businesses and individuals across Canada. They also affect inter-provincial trade flows by sustaining trade imbalances between regions. A region's own income comes from purchases of the goods and services it produces, including exports. It spends this income on other goods and services, including imports. If there are no other sources of income for a region, then its exports and imports will balance. Positive transfers, however, allow the region to purchase more, including more

Figure 1: Fiscal Transfers and Trade Imbalances (2010)

(a) Overall Trade Surplus vs Transfers

(b) Internal Trade Surplus vs Transfers



Panel (a) displays the relationship between net transfers and trade imbalances. Panel (b) displays the relationship between net transfers and internal trade imbalances (that is, excluding international trade flows). All data is for year 2010.

imports, creating a trade deficit. In our full model to come, we formalize this idea but this simple intuition suffices for now. In Panel (a) of Figure 1, we plot provincial trade surpluses against net transfers, both as a share of GDP. In Panel (b), we plot trade surpluses based on inter-provincial trade flows only.[6]

2.2 Internal Trade Costs

How integrated are Canada's product markets? Barriers to internal trade rarely take the form of explicit taxes or tariffs. Although examples exist — the Octroi in Ethiopia or the Local Body Tax in various Indian municipalities — barriers are typically non-tariff and, therefore, difficult to quantify. Consider sales taxes levied on goods purchased from another state without an offset for sales taxes paid in that other state, taxation of nonresident commercial vehicles, discriminatory liquor laws, local government procurement procedures that favour local suppliers, or restrictions on professional certifications. For Canada, Beaulieu et al. (2003) provide an anecdotal review of a wide variety of inter-provincial trade barriers, covering province-specific occupational licenses, home-biased government procurement, and local marketing boards for agricultural goods.

These examples are illustrative. In our quantitative analysis to come, we use recent and systematic evidence on the magnitude of internal trade costs in Canada from Albrecht and Tombe (2016). We reprint their main results in Table 3. The data we use is the same as in their setting and while our models differ slightly, fiscal transfers do not affect the trade cost estimates. We leave the precise details to their paper and our supplementary analysis in the appendix, and discuss here only the broad interpretation of their various measures.

[6] We use 2010 for two reasons. First, Statistics Canada data on inter-provincial trade is produced with a significantly longer lag than province-specific measures of federal revenue and spending. Second, we use trade cost estimates from Albrecht and Tombe (2016). In the appendix, we demonstrate trade cost estimates are robust to other years between 2007 and 2014 (the latest).

Table 3: Average Trade Costs Within Canada

(a) By Exporting Province

	Trade-Weighted Averages (Per Cent, Tariff-Equivalent)			
	Average Symmetric Costs	Average Export Costs	Contribution of Asymmetric Trade Costs	Contribution of Non-Distance Trade Costs
British Columbia	78.5	-11.4	6.0	10.5
Alberta	56.1	-15.5	4.1	7.2
Saskatchewan	62.8	11.9	34.1	14.3
Manitoba	74.0	-4.8	11.9	9.8
Ontario	73.5	-15.8	1.3	17.1
Quebec	62.5	-1.4	13.4	17.4
New Brunswick	66.4	7.3	16.4	24.4
Nova Scotia	85.4	14.3	19.0	31.5
Prince Edward Island	106.1	22.2	30.3	32.1
Newfoundland	47.4	-6.8	14.4	3.2
Canada	67.8	0.0	7.8	14.5

(b) By Industry

	Trade-Weighted Averages (Per Cent, Tariff-Equivalent)			
	Average Symmetric Costs	Average Export Costs	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 trade cost measures found by Albrecht and Tombe (2016). Details are in section 2.2, and the appendix.

The first column of Table 3 reports a summary measure of overall trade costs in Canada based on the Head-Ries Index (Head and Ries, 2001). The Index estimates the average trade cost between two regions, regardless of the direction of trade, relative to the cost of trading within each region (say, between cities). These estimates are unique to each importer-exporter-sector triple, and we aggregate to single summary measures in the table using trade-volume weights. Overall, this measure shows average internal trade costs of nearly 68 per cent in Canada, with larger costs in poorer regions and substantial variation across sectors. This measure is symmetric, in the sense that it does not distinguish between trade costs facing goods moving from Ontario to Quebec, say, with trade costs for goods moving from Quebec to Ontario.

But asymmetric trade costs matter in the data, and will matter in our quantitative analysis. To distinguish exporter- from importer-specific trade costs, one requires data on prices and trade flows because the two types of trade cost asymmetries have different implications for prices, but either can be consistent with observed trade flows alone. If prices in a country are high but imports are low, for example, then the cost of importing must be high. After all, in the absence of high import costs, consumers in a high-price country would import more from elsewhere. Similarly, if prices in a country are low but export flows are too, then the cost of exporting must be high. Between countries, Waugh (2010) demonstrates that export costs fit the data best, and also finds that poor countries tend to have particularly high export costs. In the appendix, we demonstrate that exporter-specific trade costs are also a key feature of internal trade between provinces in Canada. Given these results, we use exporter-specific trade costs in our model. Formally, if symmetric costs are t^j_{ni} and export costs are t^j_i then the cost of importing into region n from region i is $\tau^j_{ni} = t^j_{ni} t^j_i$. The second column of Table 3 reports the average values of t^j_i that Albrecht and Tombe (2016) measure. In general, poor regions tend to have higher export costs than rich regions. This fact will matter when we explore the gains from lower trade costs in the presence of fiscal transfers.

Of course, not all trade costs are under the control of policy makers. It will always cost more to ship from Vancouver to Toronto than from Vancouver to Calgary, for example. To quantify the magnitude of policy-relevant trade costs, Albrecht and Tombe (2016) use two measures. First, the contribution of asymmetric trade costs estimates by how much trade costs would fall if all asymmetries were removed. Intuitively, consider this exercise as the effect of harmonizing regulations across provinces. With no regulatory differences, trade costs shouldn't differ when moving from Alberta to BC versus BC to Alberta. Second, the contribution of non-distance trade costs estimates by how much trade costs would fall if only distance mattered. To estimate this, Albrecht and Tombe (2016) regress total trade costs on distance between provinces and take the residuals, which can be interpreted as non-distance costs. We provide more detail in the appendix, but report these two measures in the third and fourth columns of Table 3. We will use these two policy-relevant measures in the quantitative analysis to come.

3 A Model of Internal Trade, Migration, and Taxes

To fully quantify the consequences of fiscal integration in Canada, and examine how it interacts with internal trade costs, we require a model to formalize the interactions of interest. In this section, we build on a recent multi-sector model of trade featuring realistic input-output relationships — specifically, the model of Caliendo and Parro (2015). We augment the model in two ways. First, we explicitly distinguish internal from international trade flows. Second, federal government revenue and spending programs redistribute fiscal resources across provinces to mitigate income differences. The latter component of the model is original to this paper. The core trade components of the model are standard.

3.1 Core Components of the Model

There are $N + 1$ regions; $N = 10$ provinces of Canada plus the rest of the world aggregated as one entity. Each region is endowed with L_n workers, who are immobile between regions but perfectly mobile between sectors. All labour and product markets are perfectly competitive.

There are J sectors each producing a composite non-tradable final good using a CES technology

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

where $y_n^j(\nu)$ are individual product varieties and σ^j is the elasticity of substitution within sector j. The final good is either consumed or used as an intermediate input within region n. On the consumption side, households derive utility from these final goods through

$$U_n = \prod_{j=1}^{J} \left(C_n^j \right)^{\beta^j}, \tag{2}$$

where C_n^j is the amount of the sector-j good consumed out of Y_n^j. Households earn income from inelastically supplying labour to each sector, earning a wage w_n. A government may supplement this income through inter-provincial fiscal transfers (described later).

Goods not consumed are used as intermediates by producers of individual product varieties within region n. There is a continuum of individual product varieties within each sector, produced with labour and material inputs. Production technologies are identical within a sector except for differences in total factor productivity. Across sectors, the importance of various inputs can differ. With wages w_n and the price of sector j goods P_n^j, the cost of an input bundle is

$$c_n^j \quad \propto \quad w_n^{\phi^j} \prod_{k=1}^{J} \left(P_n^k \right)^{\gamma^{jk}\left(1-\phi^j\right)}, \tag{3}$$

where ϕ^j is labour's share and γ^{jk} is the share of intermediates purchased by sector j from sector

k. A producer with productivity φ will therefore have marginal costs c_n^j/φ.

Final goods producers will source each product variety from the lowest cost source, either at home or from another region. Products shipped between regions incur an iceberg trade cost $\tau_{ni}^j \geq 1$, where τ_{ni}^j goods must be shipped from region i in order for one unit to arrive at region n. The resulting price paid by buyers in region n for a product of sector j from region i will therefore be $\tau_{ni}^j c_i^j/\varphi$, where φ is the producer's productivity. If productivity across varieties within each sector is identically and independently distributed Frechet, with CDF $F_n^j(\varphi) = e^{-\left(\varphi/A_n^j\right)^{-\theta^j}}$, then a well known result from Eaton-Kortum models follows: the share of region n's total spending on goods from region i in sector j is

$$\pi_{ni}^j = \frac{\left(\tau_{ni}^j c_i^j/A_i^j\right)^{-\theta^j}}{\sum_{k=1}^{N+1}\left(\tau_{nk}^j c_k^j/A_k^j\right)^{-\theta^j}}, \tag{4}$$

and the sector j price index in region n is

$$P_n^j \propto \left[\sum_{i=1}^{N+1}\left(\tau_{ni}^j c_i^j/A_i^j\right)^{-\theta^j}\right]^{-1/\theta^j}. \tag{5}$$

The proportionality constant in the price index is completely irrelevant for our purposes. The parameter θ^j governs the variation of productivity across varieties and A_n^j is the location parameter corresponding to overall average productivity for region n and sector j. Given prices P_n^j of each sector's output, the overall price index for region n is

$$P_n = \prod_{j=1}^{J}\left(P_n^j\right)^{\beta^j}. \tag{6}$$

Given trade shares π_{ni}^j, total sales of sector j goods by region n is $R_n^j = \sum_i \pi_{in}^j X_i^j$, where X_i^j is region i's total expenditures on sector j goods. These expenditures originate from producers buying inputs and from consumer final demand. In the appendix, we detail how input-output linkages and intermediate input spending combine with final demand to solve for equilibrium sales R_n^j. Here, we focus only on the factors influencing household income I_n. First, labour earnings from production is total value-added $w_n L_n = \sum_j \phi^j R_n^j$. If labour income were the only source of income, trade would balance. But other sources of income can sustain trade imbalances S_n and therefore total income is $I_n = w_n L_n - S_n$. If $S_n > 0$ then region n has a trade surplus, while if $S_n < 0$ it has a deficit.

A variety of factors contribute to trade imbalances. First, there may be exogenous transfers $\bar{S}_n$ (perhaps due to private investment flows, for example). Given the data on trade imbalances S_n and government fiscal transfers T_n we presented in Section 2, exogenous sources of trade imbalances are $\bar{S}_n = S_n + T_n$. Second, a central government taxes and spends in each region. The net effect of such revenue and spending measures may be positive or negative, depending on whether central government revenue from or spending in a province is larger. We distinguish between exogenous fiscal transfers $\bar{T}_n$ and income-sensitive ones that augment labour earnings by a factor t_n. The following Proposition establishes how this term responds to wages.

Proposition 1 *With a constant elasticity ζ of fiscal transfers with respect to wage earnings $w_n L_n$, the balanced-budget income-sensitive fiscal adjustment term is given by*

$$t_n = (w_n/\bar{w})^{\zeta} \tag{7}$$

where $\bar{w} = \left[\sum_{i=1}^{N}\left(\frac{w_i L_i}{\sum_{m=1}^{N} w_m L_m}\right) w_i^{\zeta}\right]^{1/\zeta}$ is the weighted power mean of wages.

Proof: See appendix.

The parameter ζ governs the strength of income-sensitive transfers. There are no international fiscal transfers, so $t_{1+N} = 1$ always holds. Given this, and data on fiscal transfers T_n, exogenous fiscal transfers are $\bar{T}_n = T_n - (t_n - 1)w_n L_n$. In summary, region n's total income is $I_n = t_n w_n L_n + \bar{T}_n - \bar{S}_n$ or, equivalently, $I_n = w_n L_n + T_n - \bar{S}_n$.

Finally, workers are perfectly mobile across sectors but imperfectly mobile across provinces. We model regional migration costs in a flexible yet tractable way. We assume workers are heterogeneous with respect to their preference for different locations. They each draw a vector of valuations for each province from an independently and identically distributed extreme value distribution. That is, some workers value living in Prince Edward Island more highly than other workers. In addition to their location preferences, workers also care about real incomes in each province. They select where to live to maximize both real incomes and location preferences (i.e., welfare) $m_n z_n / P_n$, where z_n is their taste for province-n and $m_n = I_n/L_n$ is per capita income. And just as heterogenous productivity across product varieties influences trade patterns, heterogeneity in worker location preferences influences the allocation of employment. This can be solved in a tractable way.

Proposition 2 *If location preferences are distributed Frechet with CDF $F_n(x) = e^{-(x/\delta_n)^{-\kappa}}$, where κ governs the variation of location preference across workers and δ_n is the common valuation, the share of workers that choose to live in province-n is*

$$l_n = \frac{(m_n \delta_n / P_n)^{\kappa}}{\sum_{i=1}^{N}(m_i \delta_i / P_i)^{\kappa}} \tag{8}$$

where $l_n = \left(\frac{L_n}{\sum_{i=1}^{N} L_i}\right)$ is province-n's share of national employment.

Proof: See appendix.

If $\kappa = 0$ then workers are immobile. As κ increases, their sensitivity to real income differences increases. Importantly, one can equivalently interpret δ_n as a common preference for living in a particular province or as a kind of destination-specific migration cost. What's important for the quantitative analysis to come is that this parameter is fixed — that is, changes in fiscal transfers, trade costs, wages, prices, and so on, have no effect on δ_n.

3.2 Solving for Counterfactual Changes

Though this is a rich model with many regions, sectors, and input-output linkages, solving for the initial equilibrium and counterfactual changes is straightforward. Work by Caliendo and Parro (2015), Costinot and Rodriguez-Clare (2014), and Albrecht and Tombe (2016) solve similar models and we build on them here. Our innovation is to incorporate worker migration between regions and endogenous fiscal transfers. In the appendix, we provide full details while here we highlight only the intuition and certain key outcomes.

First, we solve for each region's initial equilibrium wages w_n given observed trade shares π^j_{ni}. Along with observed trade imbalances S_n, one can solve for initial equilibrium income levels in each province. If our goal was to estimate equilibrium wages and incomes consistent with observed trade shares from data, we would be done (and we would have learned little). Instead, our goal is to estimate counterfactual responses to policy changes — namely, fiscal transfers or changes in trade costs. Conveniently, the Exact-Hat Algebra approach of Dekle et al. (2007) is a simple yet powerful method to solve these counterfactual responses. It is increasingly used to simplify the calibration and quantitative analysis in models similar to ours, such as Caliendo and Parro (2015) and Costinot and Rodriguez-Clare (2014).

Second, from this initial equilibrium that exactly matches trade and transfer data, we solve for the equilibrium response to any change to trade costs (τ^j_{ni}) or fiscal integration (T_n or ζ). Consider moving from an initial equilibrium consistent with data to a new counterfactual equilibrium. We denote the equilibrium change in all variables as $\hat{x} = x'/x$, and write the changes in equations 3 to 5 as

$$\hat{c}^j_n = \hat{w}_n^{\phi^j} \prod_{k=1}^{J} \left(\hat{P}^k_n\right)^{\gamma^{jk}(1-\phi^j)}, \tag{9}$$

$$\hat{\pi}^j_{ni} = \left(\hat{\tau}^j_{ni}\hat{c}^j_i/\hat{P}^j_n\right)^{-\theta^j}, \tag{10}$$

$$\hat{P}^j_n = \left[\sum_{i=1}^{N+1} \pi^j_{ni}\left(\hat{\tau}^j_{ni}\hat{c}^j_i\right)^{-\theta^j}\right]^{-1/\theta^j}. \tag{11}$$

Equations 9 to 11 define a system $\hat{\boldsymbol{\pi}} = f(\mathbf{w}; \hat{\boldsymbol{\tau}})$, which maps wage changes to trade share changes, given trade cost changes. With counterfactual trade shares $\pi^{j\,\prime}_{ni} = \pi^j_{ni}\hat{\pi}^j_{ni}$, we demonstrate that one can solve for counterfactual sales of each sector and wages in each province. Trade imbalances also change in any counterfactual equilibrium. Some of the imbalances are exogenous ($\bar{S}_n$) while others are due to fiscal transfers, and therefore $S'_n = (1 - t'_n)w'_nL'_n + \bar{S}_n$. Finally, we solve for equilibrium changes in the distribution of employment from equation 8, given changes in per capita real income

$\hat{m}_n/\hat{P}_n$, with

$$l_n' = \frac{l_n \left(\hat{m}_n/\hat{P}_n\right)^{\kappa}}{\sum_{i=1}^{N} l_i \left(\hat{m}_i/\hat{P}_i\right)^{\kappa}}. \tag{12}$$

Notice $\hat{l}_n \propto \left(\hat{m}_n/\hat{P}_n\right)^{\kappa}$, and therefore κ is simply the real income elasticity of migration. There are good estimates of this available, which simplifies the calibration.

Our key outcomes of interest are real income, real wages, and employment in all regions and sectors. Real income per worker in province n is m_n/P_n, which is affected by changes in wages and transfers. The real wage in sector j and province n is simply w_n/P_n^j and therefore the real wage for province n overall is w_n/P_n. As we show in the appendix, real wages are affected by trade flows through changes in π_{nn}^j. Specifically,

$$\frac{\hat{w}_n}{\hat{P}_n} = \prod_{j=1}^{J} \left(\hat{\pi}_{nn}^j\right)^{-g^j/\theta^j} \tag{13}$$

where g^j is a term that summarizes the "influence" of sector j on the overall economy through its input-output linkages and its use in final demand. Finally, changes in provincial real wages and employment map naturally to changes in Canada's aggregate real GDP. Given provincial real wage changes $\hat{y}_n = \hat{w}_n/\hat{P}_n$ and employment changes $\hat{l}_n$, the change in national real GDP is

$$\hat{Y} = \sum_{i=1}^{N} \omega_n \hat{y}_n \hat{l}_n, \tag{14}$$

where ω_n is province n's initial share of national real GDP.

3.3 Calibrating the Model

To perform our quantitative analysis, we must calibrate parameters $\{\phi^j, \beta^j, \gamma^{jk}, \theta^j, \kappa, \zeta\}$ and set initial equilibrium values for trade and employment shares $\{\pi_{ni}^j, L_n\}$ to match data. For trade shares π_{ni}^j, we use 2010 data from Statistics Canada Table 12-10-0088-01, which provides internal and international trade, production, and expenditure data for each of Canada's provinces and for a variety of commodities and years. We map commodities in the trade and production data to ISIC Rev. 3 and aggregate them to 22 sectors for which positive production exists in all provinces. It is straightforward to calculate π_{ni}^j as the ratio of trade flows in sector j from region i to region n relative to region n's total spending on sector j goods. For employment, we use the Labour Force Survey data for 2010 from Table 14-10-0090-01.

Many of the model parameters are straightforward to calibrate, as there are readily available counterparts in the data. For production and preference parameters ϕ^j and β^j, we turn to the OECD structural analysis database (OECD STAN). The value-added-to-output ratio of each sector is ϕ^j and the shares of final demand shares allocated to each sector is β^j. We report ISIC codes, value-added to output ratios, final demand shares, and other industry characteristics in the appendix.

The inter-sectoral input shares γ^{jk} are also from the OECD STAN, though we do not report them individually.

Next, we calibrate the two Frechet parameters θ^j and κ. First, from equation 4, θ^j is the cost-elasticity of trade. Countless papers estimate these elasticities (Head and Mayer, 2014), though there are no within-country sector-specific estimates that we are aware of. Between countries, however, Caliendo and Parro (2015) estimate elasticities at a similar level of aggregation. As their model is the base upon which ours is built, we adopt their estimates. We follow Costinot and Rodriguez-Clare (2014) for sectors where Caliendo and Parro (2015) do not have estimates, and set $\theta^j = 5$. Second, from equation 8, κ is the real income elasticity of migration. We do not estimate this directly, but others find an income elasticity of migration in the range of 1.5. For example, Helliwell (1996) finds an elasticity with respect to per capita GDP and real disposable income of slightly over 1.5 for Canada. For the United States, Fajgelbaum et al. (2018) estimate $\kappa = 1.39$ within a parameterization of their model (richer than this one) that most closely resembles ours. For China, Tombe and Zhu (2018) find elasticities in the range of 1.2 and 1.6. We set $\kappa = 1.5$. In the appendix, we explore the sensitivity of our results to alternative values for both θ^j and κ.

Finally, the parameter ζ governs the strength of fiscal integration. It determines a province's income-sensitive fiscal transfers as a function of a province's underlying wage w_n and affects the size of a province's trade imbalance. We use data on fiscal transfers and trade imbalances, each relative to GDP, to calibrate ζ. In the model's initial equilibrium, $I_n = w_n L_n - S_n$ and we therefore infer $w_n L_n$ from the initial equilibrium of the model. If all transfers are due to income differences, then $T_n = (t_n - 1) w_n L_n$ and, given the results of Proposition 1, we have $log\,(1 + T_n / w_n L_n) \propto \zeta \cdot log\,(w_n)$ where the constant term (which depends on $\bar{w}^{\zeta}$) is common across regions and therefore omitted. That is, the cross-province elasticity of transfers (relative to total factor incomes, $w_n L_n$) with respect to wages pins down ζ. We estimate $\zeta = 0.33$. In the appendix, we explore alternative values for this parameter and the sensitivity of our results. Of course, as mentioned earlier, not all transfers are sensitive to income and not all of provincial trade imbalances are due to transfers. In particular, we infer exogenous trade surpluses $\bar{S}_n$ and exogenous transfers $\bar{T}_n$ by solving $T_n = (t_n - 1) w_n L_n + \bar{T}_n$ followed by $S_n = \bar{S}_n - T_n$. By construction, these exogenous terms sum to zero across all provinces.

4 Quantitative Exercises

With the full model now established, we proceed to our quantitative analysis where we change either fiscal integration or trade costs (through $\hat{\tau}^j_{ni}$). We begin with a simple experiment to gauge the effect of current fiscal transfers on incomes, wages, and migration. We then examine how the trade and fiscal transfers interact.

4.1 Gains from Fiscal Transfers

To quantify how transfers affect economic activity, we simulate moving from the initial equilibrium to one where there are no fiscal transfers. This is similar to Dekle et al. (2007)'s analysis between countries, but we hold the portion of trade imbalances unexplained by transfers constant. In what follows, we hold trade costs unchanged, so $\hat{\tau}^j_{ni} = 1$ for all (n, i, j). The resulting real income $\hat{m}_n/\hat{P}_n$, real wage changes $\hat{w}_n/\hat{P}_n$, and employment changes $\hat{L}_n$ in each region tell us the effect of removing fiscal transfers. Since the simulations involve moving from an equilibrium with transfers to one without, the inverse of the changes is therefore the effect of fiscal transfers.

Our first experiment quantifies the effect of Canada's observed between-region fiscal transfers. Specifically, we simulate a counterfactual equilibrium where $T_n = 0$, and therefore $S_n = \bar{S}_n$ for all provinces. We find such transfers have large effects on real incomes and migration, though limited effects on real wages. Our main estimates are in the first three columns of Table 4. Real income gains in poor regions are large and losses in rich regions are equally so. This fits our earlier intuition well. Trade deficits are the source of income gains, and recipient provinces (provinces with positive net fiscal transfers) have large deficits and contributor provinces have large surpluses. We find relatively small effects on real wages, with changes ranging from a 0.6 per cent gain in Nova Scotia to a 0.2 per cent loss in Newfoundland and Labrador. These limited changes are due to migration. While financial inflows increase wages more than prices in recipient regions, the resulting migration inflow mostly offsets this effect. The results without inter-provincial migration are displayed in the bottom panel of Table 4. We find employment increases by roughly one quarter in New Brunswick and Nova Scotia, and as much as nearly 50 per cent in Prince Edward Island. Alberta, meanwhile, has employment that is over 12 per cent smaller due to fiscal transfers. This reallocation of labour has large implications for Canada's aggregate real GDP, which we find falls by 0.84 per cent — equivalent to nearly \$19 billion today.

One component of fiscal transfers is particularly salient in Canada: equalization payments. We explore the implications of such payments within the model by removing them from the initial equilibrium. Specifically, we simulate $S'_n = \bar{S}_n - T_n + \tilde{e}_n$, where $\tilde{e}_n = e_n I_n - \sum_i e_i I_i \left(\frac{I_i}{\sum_m I_m}\right)$ is the net change in fiscal transfers from eliminating equalization and returning proceeds to each province proportional to their GDP. The parameter e_n is actual equalization received in 2010 as a share of provincial GDP, which ranged from 0.2 per cent for Ontario to 6.3 per cent for PEI. We display the results in the final three columns of Table 4. As with other transfers, recipient provinces benefit from higher real income and real wages, with one exception. Ontario received a relatively small payment in 2010 relative to its overall contribution to federal government revenue, and its real income would increase if equalization were eliminated. On migration, just under 1 per cent of Canada's employment migrates across provinces as a result of equalization, with the largest flows between Ontario and Quebec. The former's population share fell 0.6 percentage points while the latter gained a similar proportion. Proportionally, employment increases the most in the Maritime provinces, increasing by as much as 7 per cent in Prince Edward Island. The aggregate effect of the equalization program is not trivial. We find national real GDP is 0.16 per cent lower — equivalent to

Table 4: Effect of Inter-Provincial Transfers (Per Cent Changes)

	All Fiscal Transfers			Equalization Only		
Region	Real Income	Real Wage	Emp.	Real Income	Real Wage	Emp.
BC	-1.7	-0.1	-2.8	-0.9	0.0	-1.3
AB	-8.3	0.0	-12.5	-1.1	0.0	-1.7
SK	-0.9	0.0	-1.6	-1.0	0.0	-1.6
MB	7.2	-0.1	10.6	2.3	0.0	3.5
ON	-0.8	0.0	-1.5	-0.8	0.0	-1.2
QC	3.4	0.1	4.8	1.6	0.0	2.5
NB	15.6	0.1	23.8	3.9	0.0	5.9
NS	17.1	0.6	26.3	1.7	0.1	2.5
PE	29.8	0.1	47.3	4.6	0.1	7.0
NL	10.4	-0.2	15.6	-1.0	0.0	-1.5
No Migration ($\kappa = 0$)						
BC	-1.9	-0.2	0.0	-1.0	-0.1	0.0
AB	-8.5	-0.4	0.0	-1.0	0.0	0.0
SK	-0.7	0.0	0.0	-1.0	0.0	0.0
MB	8.1	0.6	0.0	2.7	0.2	0.0
ON	-0.8	-0.1	0.0	-0.9	-0.1	0.0
QC	3.6	0.3	0.0	1.8	0.1	0.0
NB	16.6	1.0	0.0	4.8	0.4	0.0
NS	20.2	1.6	0.0	2.2	0.2	0.0
PE	31.3	2.3	0.0	6.1	0.6	0.0
NL	7.8	0.1	0.0	-1.0	-0.1	0.0

Displays the per cent change in real incomes, real wages, and employment as a result of observed inter-provincial fiscal transfers.

roughly \$3.5 billion today, or approximately one-fifth of the total size of the equalization program.[7]

Next, we estimate the effect of income-sensitive transfers only — that is, the subset of federal revenue and spending programs that respond endogenously to a province's average income. This exercise holds fixed those transfers unrelated to a province's underlying economic strength, such as defence spending in Halifax or general government spending in and around Ottawa. We display the results in Table 5. The overall pattern of real income and real wage changes are similar to the effect of transfers overall. Income shrinks in contributor regions — by as much as 10 per cent in Alberta — and employment migrates towards lower income regions. As with transfers overall, migration almost fully mitigates the effect of transfers on real wages but results in misallocated labour that lowers Canada's aggregate real GDP by just over 1.2 per cent.

[7]In the appendix, we explore the aggregate implications of equalization in a model that explicitly incorporates source-based provincial tax revenues. This is typically the focus of quantitative studies of equalization, and we find our results change only slightly. As equalization is not our primary focus, abstracting from source-based revenues simplifies the model without overly biasing the results.

Table 5: Effect of Interprovincial Income-Sensitive Transfers (Per Cent Change)

Region	With Migration Response			No Migration		
	Real Income	Real Wage	Emp.	Real Income	Real Wage	Emp.
BC	5.0	-0.1	6.9	5.6	0.4	0.0
AB	-10.1	0.0	-15.3	-10.6	-0.6	0.0
SK	-7.2	0.1	-11.2	-7.6	-0.4	0.0
MB	5.6	-0.1	7.8	6.5	0.5	0.0
ON	-0.3	0.0	-1.2	-0.4	0.0	0.0
QC	5.7	0.1	7.9	6.0	0.4	0.0
NB	0.8	0.1	0.5	0.8	0.0	0.0
NS	5.3	0.2	7.2	6.8	0.6	0.0
PE	16.3	0.1	24.5	19.6	1.6	0.0
NL	-2.1	0.1	-3.8	-2.1	-0.2	0.0

Displays the effect of fiscal transfers on real incomes, real wages, and employment. The case without a migration response imposes $\kappa = 0$, which holds the distribution of employment across provinces fixed.

4.2 Interaction Between Fiscal Transfers and Trade Costs

To quantify the aggregate effect of inter-provincial transfers, both trade and migration are important to consider. To show this, we first estimate the effect of transfers with and without trade and migration responses. Specifically, we hold both the distribution of employment L_n and trade shares π^j_{ni} fixed at their initial equilibrium values. We report the results in Table 6. Though the effect of transfers on provincial real incomes does not vary across model specifications, aggregate effects exhibit wide variation. Without trade or migration responses, transfers do not affect aggregate real GDP, only its distribution across provinces. With migration, however, workers move in response to fiscal benefits rather than underlying fundamentals. This misallocation lowers aggregate real GDP by 0.3 per cent. With trade, the number of workers that migrate increases significantly. In our baseline results, Alberta's employment is over 12 per cent lower as a result of transfers while PEI's is nearly 50 per cent higher. Without trade, those values shrink to a 5 per cent loss for Alberta and 16 per cent gain for PEI. And with more migration comes a larger aggregate loss, with real GDP falling 0.84 per cent when both trade and migration can respond to transfers. The literature on the aggregate effects of transfers has highlighted the important role of inter-provincial migration, but has abstracted from the role of trade. With trade responses, transfers will increase wages more than prices in recipient regions, and therefore encourage more migration than a model without trade where real wages are unaffected by transfers. Workers will respond to this real wage increase and therefore the migration response is larger in a model with trade than in one without. Moreover, trade means a province's wages fall by less as more workers move in, since higher employment will increase export demand for that province's goods.

Moreover, trade costs contribute to fiscal transfers by increasing cross-province income differences, and therefore federal revenue and spending programs that are sensitive to income become

Table 6: Trade and Migration Responses Matter for the Aggregate Effect of Transfers

Region	Per Cent Change in Real Income			Per Cent Change in Employment	
	With Both Trade and Migration Response	Migration Response Only	No Trade or Migration Response	With Trade Response	No Trade Response
BC	-1.7	-1.7	-1.5	-2.8	-1.3
AB	-8.3	-8.1	-8.3	-12.5	-5.1
SK	-0.9	-0.7	-0.8	-1.6	-0.6
MB	7.2	7.4	7.3	10.6	4.2
ON	-0.8	-0.8	-0.8	-1.5	-0.7
QC	3.4	3.3	3.3	4.8	1.8
NB	15.6	15.5	15.5	23.8	8.8
NS	17.1	17.1	15.5	26.3	10.1
PE	29.8	28.9	29.7	47.3	15.9
NL	10.4	8.5	9.9	15.6	4.3
Aggregate Real GDP Effect of Observed Transfers (Per Cent)					
Canada	-0.8	-0.3	0	-	-

Displays the effect of fiscal transfers on real income and employment, by province and in aggregate, across three scenarios. First, both trade flows and migration can respond. Second, employment is allowed to move as workers make optimal migration decisions. Finally, trade shares π^j_{ni} are held fixed at their initial values, as is employment.

more redistributive. To estimate the effect of trade costs on transfers, we re-estimate the model with lower trade costs. Following a uniform 10 per cent reduction in internal trade costs, interprovincial transfers decline by 4 per cent. If both internal and external trade costs decline by 10 per cent, interprovincial transfers decline by 7 per cent. Policy-relevant trade costs reported in Section 2.2 also matter. After removing trade cost asymmetries, for example, fiscal transfers fall from their initial level of 1.9 per cent of GDP to 1.6. Alternatively, after removing non-distance trade costs, fiscal transfers decline to less than 1.8 per cent of GDP. In an important sense, policy-relevant internal trade costs account for between 4 to 12 per cent of observed fiscal transfers. Today, that is roughly equivalent to between $1 and $4 billion per year. This is relevant. Policy makers in Canada are striving to lower internal trade costs — through various initiatives, but in particular the new *Canadian Free Trade Agreement* — and inter-provincial fiscal transfers are also a pressing political issue for some, especially in Alberta. These results demonstrate that internal trade liberalization can help contribute to lower inter-provincial transfers by reducing regional income inequality.

Finally, transfers affect the distribution of gains from trade, because if trade costs are infinite there can be no effect from fiscal transfers. Consider moving all provinces to autarky by simulating $\hat{\tau}^j_{ni} \to \infty$ for all trading pairs $n \neq i$ and sectors j. Comparing counterfactual real incomes, real wages, and employment to the initial equilibrium reveals the gains associated with the observed

Table 7: Gains from Observed Trade Relative to Autarky

Region	Per Cent Change in		
	Real Income	Real Wage	Employment
BC	29.9	21.4	15.4
AB	6.0	18.3	-14.9
SK	19.0	29.0	1.3
MB	36.4	24.2	24.2
ON	11.3	13.5	-8.4
QC	21.1	16.2	3.9
NB	63.4	41.7	62.9
NS	56.9	23.5	53.3
PE	66.5	32.5	67.5
NL	35.7	49.4	23.3

Displays per cent change in real incomes, real wages, and employment for each province relative to a counterfactual equilibrium of no trade (autarky).

level of inter-provincial and international trade. We display these results in Table 7. Real income gains and real wage gains are often substantially different. In particular, fiscal transfers amplify income gains from trade for relatively poor regions and dampen them for rich regions. This is because moving to autarky not only eliminates the gains from trade, but also completely eliminates any effect that fiscal transfers have on real income or real wages. Without trade, there can be no trade imbalance and therefore no scope for net financial inflows to raise incomes more than prices. For rich regions, the opposite is the case. In this sense, trade and fiscal integration complement each other.

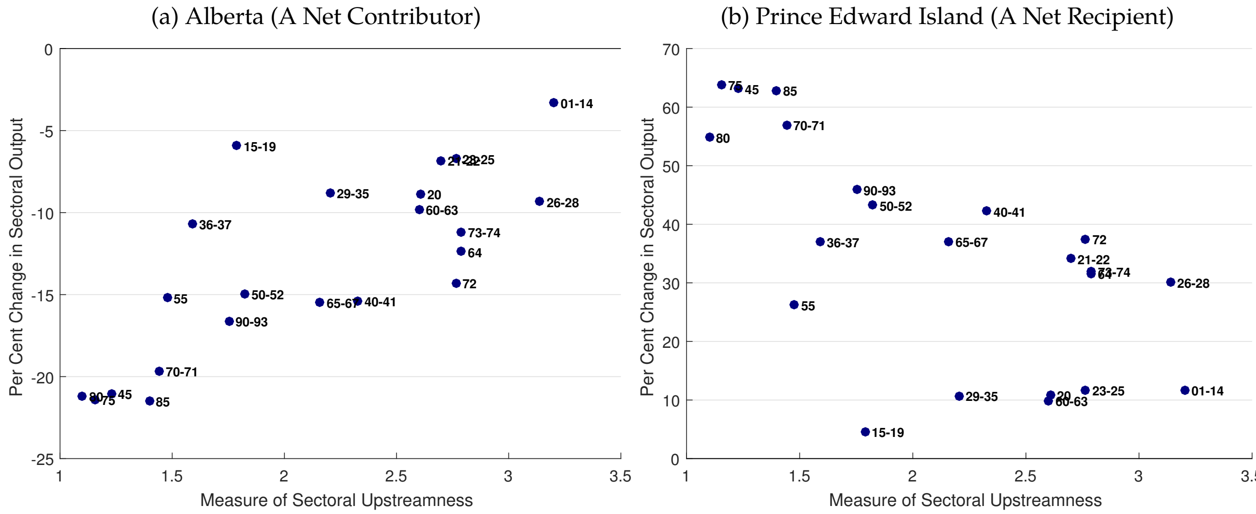
4.3 Effect of Fiscal Transfers on Within-Province Industrial Structure

Not only are there overall gains and losses for provinces from fiscal transfers, but there are also within-province effects. The relative size of different sectors responds to fiscal transfers. Fiscal transfers change a province's level of household income, after all, and if income rises then sectors that produce goods mainly for final consumption will expand, bidding up wages. Sectors producing mainly intermediate inputs will see rising costs but do not experience as large an increase in demand. The reverse will hold in provinces whose incomes decline due to fiscal transfers. To investigate this formally, we must define a notion of how far a sector is from final consumers. Sectors that are "far" from final consumers are "upstream" sectors.

How can we measure upstreamness? Let's start with the classic notion of forward linkages. Consider a matrix $\tilde{\mathbf{B}}$ collecting the share of each sector's output going to each other sector as inputs.[8] That is, the element in the i^{th} row and j^{th} column is the share of sector i's output used

[8] This is a direct corollary of the input matrix $\tilde{\mathbf{A}}$ described in the appendix. In a single-region closed-economy version of our model, sectoral output would be exactly $\mathbf{R} = (\mathbf{I} - \tilde{\mathbf{A}})^{-1}\boldsymbol{\alpha}$. The elements of the output matrix $\tilde{\mathbf{B}}$ would then be $\gamma^{kj}(1-\phi^k)R^j/R^k$ for the k^{th} row and j^{th} column. It is straightforward to show $\tilde{\mathbf{B}} = \hat{\mathbf{R}}^{-1}\tilde{\mathbf{A}}\hat{\mathbf{R}}$, where (with an abuse of our hat-notation) $\hat{\mathbf{R}}$ is a diagonal matrix of the vector $\mathbf{R}$.

Figure 2: Within-Province Effect of Fiscal Transfers



Displays the change in industry output (equivalently real value-added) in Alberta and PEI. Industry codes are ISIC Rev. 3 two-digit codes. These patterns are representative of all net contributors and net receipients of fiscal transfers. The horizontal axis is each industry's upstreamness, as measured by the average number of production stages away from final consumption. It also corresponds to the classic total forward linkage measure as the row-sum of a Ghosh Inverse Matrix. See section 4.3 for details.

by sector j as inputs. The row-sum of this matrix is a measure of each sector's direct forward linkages. There are also indirect forward linkages, as supplying inputs to sector j is indirectly supplying inputs to any sector supplied by sector j. The total direct and indirect forward linkages is the row-sum the so-called Ghosh Inverse Matrix $(\mathbf{I} - \tilde{\mathbf{B}})^{-1}$. Sectors with many forward linkages are considered upstream.

This forward linkage measure has a very long history, though more recently Fally (2012) develops another measure of a sector's "distance" to final consumers. If a sector sells output to relatively upstream sectors, then Fally (2012) posits that this sector is also upstream. He defines upstreamness of sector j as $u^j = 1 + \sum_k b^{jk} u^j$, where b^{jk} are the elements of the output matrix $\tilde{\mathbf{B}}$ just described. Solving this equation yields $\mathbf{u} = (\mathbf{I} - \tilde{\mathbf{B}})^{-1}\boldsymbol{\iota}$, where $\boldsymbol{\iota}$ is a $J \times 1$ vector of ones, which is the classic total forward linkage measure described in the previous paragraph. Antras et al. (2012) show that this measure is also equivalent to the average number of production stages each sector's output is from final consumers. We proceed with this intuition in mind.

In autarky, the average upstreamness of all provinces is the same, as household preferences and production technologies are the same across all regions. Without trade, the distribution of economic activity across sectors will therefore be the same. With trade, specialization takes place and different regions expand output of different sectors relative to others — comparative advantage at work. It turns out that in the data, higher income regions tend to concentrate relatively more in upstream sectors. This is consistent with recent evidence that upstreamness in international exports increases with a country's income (Antras et al., 2012).

Fiscal transfers, however, also affect the pattern of specialization. We discussed the intuition at the beginning of this section and display our quantitative results in Figure 2. We plot the effect of fiscal transfers on each sector for two provinces, Alberta and Prince Edward Island. That is, we compare each industry's size in the initial equilibrium with a counterfactual equilibrium with $T_n = 0$ and therefore $S_n = \bar{S}_n$. For Alberta, there is a clear positive relationship between a sector's upstreamness and the change in its output. Relatively upstream sectors do better than downstream ones. For PEI, the effect is reversed. This confirms the intuition with which we opened this section. Provinces that receive net transfers see downstream sectors expand relative to upstream sectors. Interestingly, while provinces that are net contributors experience real income and real wage losses, different sectors are affected differently. Upstream sectors within net contributing provinces, for example, see share of a province's overall economy increase due to transfers while downstrem sectors see their shares decrease. Equivalently, there is a spatial reallocation of economic activity: upstream sectors shift towards higher income provinces. Across all provinces, the effect varies. Alberta's upstreamness measure is two per cent larger than it would be without fiscal transfers, while Nova Scotia and PEI see their upstreamness decline by 3.6 and 4.6 per cent, respectively. This is quantitatively important, as the variation across provinces is relatively small. Average upstreamness is just over 2, with a standard deviation of 0.12. The increase in Alberta's upstreamness is therefore nearly half of a standard deviation whereas the decline in PEI is equivalent to nearly 80 per cent of a standard deviation. Finally, as higher income provinces tend to be more upstream than lower income provinces, transfers increase the variation in upstreamness across provinces. We find the standard deviation of upstreamness increases by 11 per cent due to transfers.

4.4 Gains from Lower Internal Trade Costs

We've explored the effects of fiscal transfers, and how they interact with trade. Next, we turn to the gains from lower trade costs using estimates of trade costs described in Section 2.2 and Table 3 in particular. The experiments we consider here eliminate these trade costs by simulating $\hat{\tau}^j_{ni} = 1/\tau^j_{ni}$. The strength of fiscal integration is held constant at $\zeta = 0.33$ and the income-sensitive transfers respond endogenously. We report the resulting change in real income, real wages, and employment for each province in Table 8.

Lowering policy-relevant trade costs involves eliminating trade cost asymmetries or trade costs unrelated to distance. Policy makers, of course, cannot change the fact that it will always be more costly to ship a good from Ontario to British Columbia than it is to ship from Ontario to Quebec. Both experiments reflect that fact. In the appendix, we provide more detail behind how these trade costs are estimated. Intuitively, removing trade cost asymmetries involves setting the trade costs between Alberta and BC, for example, to lower of the cost of shipping from BC to Alberta or from Alberta to BC. Removing trade costs unrelated to distance involves eliminating only the residual in a regression of bilateral trade costs on distance across all province pairs. In addition to policy-relevant trade cost changes, we also report the effect of eliminating all internal trade costs. These counterfactuals mirror Albrecht and Tombe (2016), but our results differ. Gains are still

Table 8: Gains from Lower Internal Trade Costs (Per Cent)

	Asymmetric Costs			Non-Distance Costs			All Internal Costs		
	Real Income	Real Wages	Emp.	Real Income	Real Wages	Emp.	Real Income	Real Wages	Emp.
BC	2.8	2.7	-0.6	4.9	4.6	-2.4	59.3	60.2	8.2
AB	3.1	2.5	-0.1	6.3	6.0	-0.3	56.8	54.4	5.6
SK	3.9	8.4	1.1	15.9	16.1	13.4	74.2	85.3	23.6
MB	3.6	4.9	0.6	7.9	7.7	1.9	81.5	93.7	31.5
ON	4.1	2.9	1.3	3.9	3.8	-3.8	38.4	32.1	-12.5
QC	1.9	2.5	-1.8	7.0	7.0	0.6	44.9	45.8	-6.2
NB	2.8	7.2	-0.6	19.2	24.5	18.3	79.8	109.8	29.7
NS	2.1	6.3	-1.6	14.4	19.6	11.2	77.2	110.6	26.9
PE	6.5	15.3	4.8	23.9	29.0	25.4	144.9	199.8	106.1
NL	3.2	5.0	0.0	24.3	22.5	26.0	102.4	109.4	54.8

Displays the effect on real income, real wages and employment from lowering various measures of internal trade costs. The difference between real income and real wages is due to fiscal transfers.

large, with aggregate real GDP increasing 3.3 per cent from removing trade cost asymmetries to nearly 7.3 per cent from removing non-distance costs. We estimate large employment responses as workers tend to migrate towards lower income regions. Overall, removing trade cost asymmetries shifts 0.6 per cent of Canada's work force to another province. Removing non-distance trade costs leads 1.8 per cent to move. We also find large differences between a province's real income gain and its real wage gain.

In general, income gains in poor regions are systematically smaller than wage gains because fiscal inflows to those regions decline as wages rise. Put another way, internal trade liberalization lowers cross-province income differences and therefore federal revenue and spending programs that are sensitive to income become more evenly distributed across regions. Models of internal trade that abstract from fiscal integration will tend to overestimate gains to lower income regions and underestimate gains to higher income ones. This is particularly true for asymmetric trade cost changes, as lower income regions tend to have higher exporter-specific trade costs. This reveals an important way in which trade cost changes interact with fiscal transfers: the direction of trade cost changes matters. Lowering export costs tends to increase wages, whereas lowering import costs tends to decrease prices. And asymmetric trade costs are such that it is typically more costly to export from poor regions than it is from rich ones. Eliminating these asymmetries therefore causes larger wage increases in poor regions, which lowers their transfer payments. The reverse effect happens in rich regions. This is a previously unexplored and quantitatively significant effect.

To cleanly illustrate the difference between import cost reductions and export cost reductions, we report in Table 9 the effect of lowering one or the other for each province. That is, we simulate reductions in the cost of importing into (or exporting out of) each province, in sequence, one at a time. Lowering import costs in Prince Edward Island, for example, results in real income and real wage gains of 5 per cent. And since the source of these gains are predominately from lower prices, transfers into the province are largely unaffected. If we instead lower the cost of exporting from

Table 9: Unilateral Reduction of Import and Export Costs (Per Cent)

Province	Gains from 10 Per Cent Lower Import Costs			Gains from 10 Per Cent Lower Export Costs		
	Real Income	Real Wages	Transfers	Real Income	Real Wages	Transfers
BC	4.3	4.2	0.1	1.0	3.7	-2.6
AB	4.6	4.4	0.2	1.6	4.0	-2.3
SK	5.4	5.6	-0.2	1.8	5.1	-3.1
MB	4.8	5.1	-0.3	1.1	4.5	-3.2
ON	4.4	4.2	0.2	2.1	3.7	-1.5
QC	4.4	4.3	0.1	1.4	3.8	-2.3
NB	5.0	7.7	-2.6	1.2	7.1	-5.5
NS	4.1	5.3	-1.2	0.3	4.7	-4.2
PE	4.9	5.0	0.0	1.1	4.3	-3.0
NL	6.4	6.0	0.4	2.8	5.5	-2.6

Displays the per cent change in real incomes, real wages, and fiscal transfers if each province unilateral lowers its import or export costs by 10 per cent. That is, the "BC" row reports the results of a single experiment where the cost of importing into (or exporting from) BC falls by 10 per cent, and trade costs between all other pairs remain unchanged. Similar, and separate, experiments are run for each province. The collected results are reported here.

PEI, real income increases only 1.1 per cent while real wages increase 4.3 per cent. In this case, most of the gains are the result of higher wages, which results in lower transfers from income-sensitive federal programs. And there's nothing special about PEI in this case, as the pattern holds across provinces. Income-sensitive federal revenue and spending programs shrink the gains from lower export costs but have only minor effects on gains from lower import costs.

4.5 Selective Trade Deals and Fiscal Integration

We end our analysis by looking at trade agreements between only a subset of provinces. Although the new Canadian Free Trade Agreement between all provinces hopes to lower internal trade barriers throughout the country, there is a growing trend for various subsets of provinces to make more detailed and comprehensive deals among themselves. BC, Alberta, and Saskatchewan established the New West Partnership Agreement, for example, which Manitoba recently joined. This seeks to harmonize regulations and lower barriers to trade in goods and workers between the provinces and improve procurement rules. The Ontario-Quebec Trade and Cooperation Agreement seeks to do the same. An agreement among Atlantic Canadian provinces to harmonize trucking regulations, which lowers inter-provincial trade costs, is another example. In the international trade literature, it is well known that bilateral deals can create trade diversion effects that can harm non-members. The same basic logic applies within a country, but does fiscal integration allow all regions to benefit from bilateral deals? After all, what benefits some provinces will cause them to implicitly contribute more to inter-provincial transfers, spreading some of the gains. We quantitatively explore this possibility.

Table 10: Lowering Trade Costs Between Selected Provinces (Per Cent)

	Effect of 10 Per Cent Lower Trade Costs Between					
	BC-Alberta-Sask		Ontario-Quebec		Maritimes (NB-NS-PE)	
Province	Real Income	Emp.	Real Income	Emp.	Real Income	Emp.
BC	1.26	1.10	0.34	-0.94	0.02	-0.04
AB	1.07	0.82	0.31	-0.98	0.02	-0.04
SK	2.24	2.58	0.30	-0.99	0.02	-0.04
MB	0.22	-0.45	0.33	-0.96	0.02	-0.04
ON	0.22	-0.44	1.11	0.21	0.02	-0.04
QC	0.23	-0.44	1.82	1.26	0.02	-0.05
NB	0.24	-0.42	0.31	-0.99	0.47	0.62
NS	0.24	-0.41	0.35	-0.93	0.44	0.59
PE	0.24	-0.42	0.31	-0.99	1.80	2.64
NL	0.20	-0.48	0.26	-1.06	0.01	-0.06
With No Fiscal Transfers ($S_n = \bar{S}_n$)						
BC	1.94	2.18	0.02	-1.49	0.00	-0.11
AB	1.26	1.16	-0.03	-1.56	0.00	-0.11
SK	2.68	3.29	-0.03	-1.56	0.00	-0.11
MB	-0.02	-0.75	0.00	-1.51	0.00	-0.11
ON	0.01	-0.70	1.19	0.25	0.00	-0.11
QC	0.00	-0.73	2.46	2.15	0.00	-0.11
NB	-0.03	-0.76	-0.13	-1.70	1.03	1.43
NS	-0.04	-0.78	-0.08	-1.63	1.35	1.92
PE	-0.01	-0.74	0.00	-1.51	2.88	4.24
NL	-0.02	-0.75	0.04	-1.45	0.01	-0.09

Displays the per cent change in real income and employment in all regions resulting from a liberalization between only certain regions lowering trade costs. These are three separate experiments, where the provinces indicated in the header lower bilateral trade costs by 10 per cent; that is, $\hat{\tau}^j_{ni} = 0.9$ for all provinces within the set indicated. All other trade costs are unchanged. Real wage effects are negligible, and therefore not reported.

We simulate lowering trade costs between certain provinces by 10 per cent. Specifically, we set $\hat{\tau}^j_{ni} = 0.9$ if n and i are both within the group of provinces liberalizing, and $\hat{\tau}^j_{ni} = 1$ otherwise. As before, the strength of fiscal integration is held constant and income-sensitive transfers respond endogenously to changing economic circumstances in each province. We choose the sets of provinces to correspond to the three examples of selective agreements just mentioned, though this is by no means an analysis of those agreements. In Table 10, we report the effect on each province's real income and employment from this hypothetical trade liberalization.

The aggregate effect of liberalization, even among a subset of provinces, is to increase Canada's overall real GDP. We estimate 0.7 per cent higher real GDP if trade costs decline by 10 per cent between the three western provinces. Aggregate gains exceed 0.8 per cent for the same liberalization between Ontario and Quebec. Given their relatively small size, however, liberalization among the three Maritime provinces has only a minor aggregate effect of 0.05 per cent, though their own individual gains are meaningful. Given these aggregate gains, there is scope for inter-provincial fiscal transfers to spread the gains even to provinces not participating in the liberalization.

Indeed, we find fiscal transfers create gains for all provinces in each of the scenarios we explore. In the first panel of Table 10, we report the effect on each region's real income and employment. In the second, we report alternative results in a model without fiscal transfers. Comparing the two, we see that all regions experience real income gains when only certain provinces liberalize trade. As regions liberalizing trade see incomes rise, they contribute more to federal revenue and receive less in federal spending. As fiscal resources are redistributed to other regions, their real incomes increase too. Fiscal transfers spread the gains from selective trade liberalization. However, in a model without fiscal transfers, regions not included in the deal to liberalize trade see their real incomes fall.

Workers also migrate towards regions that liberalize trade, away from those that do not, though fiscal transfers dampen the magnitude of such movements. For the three original provinces within the New West Partnership Agreement, for example, employment rises by as much as 2.6 per cent in Saskatchewan and just over 0.8 per cent in Alberta if trade costs decline by 10 per cent. Without fiscal transfers, however, the resulting migration flows would be larger. We estimate a 3.3 per cent increase in employment in Saskatchewan, 2.2 per cent increase in British Columbia, and a 1.2 per cent increase in Alberta, for example, when those three provinces liberalize. In effect, fiscal transfers reduce the incentive to migrate into liberalizing provinces because some of the gains are being spread to all provinces.

5 Conclusion

Fiscal transfers between regions to alleviate income disparities are very common. Even absent explicit programs, equalization is often a simple consequence of having a large federal government. While a substantial body of work studies the effects of fiscal integration, and its effect on regional migration, the literature typically abstracts from trade. We demonstrate the income and employment consequences of fiscal integration, both for each province and Canada's aggregate economy, depend crucially on trade. To do this, we expand an otherwise standard quantitative trade model to feature both endogenous fiscal transfers and imperfect worker mobility, which we calibrate with detailed data on trade and financial flows between Canadian provinces.

Through various counterfactual simulations, we find income and employment in recipient (lower income) regions increase, sometimes dramatically so. The reverse is true in contributor (rich) regions. Real income gains to poor provinces are on the order of 15 to 30 per cent while real income losses in higher income provinces can exceed 8 per cent. Employment in poor regions also increases, by between 25 and 50 per cent, while employment in Alberta declines more than 12 per cent. In aggregate, this migration reduces Canada's overall productivity as workers move to capture fiscal benefits rather than respond to more fundamental factors like provincial productivity. We find aggregate real GDP in Canada is 0.8 smaller due to fiscal transfers — a larger efficiency loss than previous research that abstracts from trade suggests. We also uncover quantitatively important effects of fiscal transfers on trade flows, specialization patterns, gains from trade, and the effect of trade policy. Transfers represent a demand shock to downstream industries, disproportionately expanding them in recipient regions relative to upstream industries; in contributor regions, the reverse is true. Finally, we find fiscal integration greatly increases the dispersion of gains from trade across Canada's provinces – amplifying gains for lower income provinces and dampening them elsewhere. Gains from trade policy changes are also affected. Gains to poor regions from asymmetric trade cost reductions are dramatically shrunk as fiscal transfers are effectively clawed-back in regions whose wages rise. Bilateral trade deals, which typically harm non-members, actually benefit everyone when fiscal integration is sufficiently strong. Overall, this research uncovers novel results of the effects of fiscal integration on the distribution of employment and economic activity in Canada.

References

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

Daron Acemoglu, Ufuk Akcigit, and William Kerr. Networks and the Macroeconomy: An Empirical Exploration. *NBER Macroeconomics Annual*, 30(1):273–335, 2016.

Delina Agnosteva, James Anderson, and Yoto Yotov. Intra-national Trade Costs: Measurement and Aggregation. *NBER Working Paper 19872*, 2014.

David Albouy. Evaluating the efficiency and equity of federal fiscal equalization. *Journal of Public Economics*, 96(9-10):824–839, 2012.

Lukas Albrecht and Trevor Tombe. Internal trade, productivity, and interconnected industries: A quantitative analysis. *Canadian Journal of Economics*, 49(1), 2016.

Treb Allen and Costas Arkolakis. Trade and the topography of the spatial economy. *The Quarterly Journal of Economics*, 3(129):1085–1140, 2014.

Pol Antras, Davin Chor, Thibault Fally, and Russell Hillberry. Measuring the Upstreamness of Production and Trade Flows. *American Economic Review*, 102(3):412–16, 2012.

David Atkin and Dave Donaldson. Who's getting globalized? the size and nature of intranational trade costs. *NBER Working Papers*, 21439, 2015.

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

Robin Boadway and Frank Flatters. Efficiency and equalization payments in a federal system of government: A synthesis and extension of recent results. *The Canadian Journal of Economics*, 15 (4):pp. 613–633, 1982.

Robin Boadway and Anwar Shah. *Intergovernmental Fiscal Transfers : Principles and Practice*. Number 7171 in World Bank Publications. The World Bank, September 2007.

James M. Buchanan. Federalism and fiscal equity. *The American Economic Review*, 40(4):583–599, 1950.

James M Buchanan. Federal grants and resource allocation: A reply. *Journal of Political Economy*, 60(6):536–538, 1952.

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

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

Kerem Cosar and Pablo Fajgelbaum. Internal geography, international trade, and regional specialization. *American Economic Journal: Microeconomics*, 8(1):24–56, 2016.

Arnaud Costinot and Andres Rodriguez-Clare. Trade theory with numbers: Quantifying the consequences of globalization. In Gita Gopinath, Alhanan Helpman, and Kenneth Rogoff, editors, *Handbook of International Economics*, volume 4. Elsevier, 2014. Chapter 4.

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

Jonathan Eaton and Samuel Kortum. Technology, geography, and trade. *Econometrica*, 70(5): 1741–1779, 2002.

Paolo Epifani and Rosario Crino. Trade imbalances, export structure and wage inequality. *The Economic Journal*, 124(576):507–539, 2014.

Paolo Epifani and Gino Gancia. Global imbalances revisited: The transfer problem and transport costs in monopolistic competition. *Journal of International Economics*, 108:99 – 116, 2017.

Pablo D Fajgelbaum, Eduardo Morales, Juan Carlos Suárez Serrato, and Owen M Zidar. State taxes and spatial misallocation. *Review of Economic Studies, forthcoming*, 2018.

Thibault Fally. Production Staging: Measurement and Facts. *Working Paper*, 2012.

Keith Head and Thierry Mayer. Gravity equations: Workhorse,toolkit, and cookbook. In Gita Gopinath, Alhanan Helpman, and Kenneth Rogoff, editors, *Handbook of International Economics*, volume 4. Elsevier, 2014. Chapter 3.

Keith Head and John Ries. Increasing returns versus national product differentiation as an explanation for the pattern of u.s.-canada trade. *American Economic Review*, 91(4):858–876, 2001.

John Helliwell. Convergence and migration among provinces. *The Canadian Journal of Economics*, 29(1):S324–S330, 1996.

Charles Jones. Misallocation, economic growth, and input-output economics. In *Advances in Economics and Econometrics*, volume 2. Cambridge University Press, 2013.

Dennis Novy. Gravity redux: Measuring international trade costs with panel data. *Economic Inquiry*, 51(1):101–121, 2013.

Stephen J. Redding. Goods trade, factor mobility and welfare. *Journal of International Economics*, 101:148–167, 2016.

Trevor Tombe. Final, unalterable (and up for negociation): Federal-provincial transfers in canada. *Canadian Tax Journal, forthcoming*, 2018.

Trevor Tombe and Xiaodong Zhu. Trade, migration and regional income differences: Evidence from china. *Working Paper*, 2018.

William G. Watson. An estimate of the welfare gain from fiscal equalization. *Canadian Journal of Economics*, 19(2):298–308, 1986.

Michael E. Waugh. International trade and income differences. *American Economic Review*, 100(5), 2010.

L. S. Wilson. Equalization, efficiency and migration: Watson revisited. *Canadian Public Policy*, 29 (4):385–396, 2003.

Appendix

Supplementary Material and Analysis

Table 11: Provincial Data and Initial Equilibrium Values

Province	Emp. Share	Transfer to Income Ratio T_n/I_n	Surplus to Income Ratio S_n/I_n	Share of National Factor Income $w_n L_n$	Share of National Total Income I_n	Relative Per Capita Income	Average Upstream-ness
BC	12.9%	-1.5%	-6.5%	11.1%	11.9%	0.92	1.97
AB	12.0%	-8.5%	11.6%	16.7%	15.0%	1.25	2.18
SK	3.0%	-0.4%	8.4%	3.8%	3.5%	1.17	2.17
MB	3.8%	7.3%	-8.9%	3.2%	3.5%	0.92	1.97
ON	38.4%	-0.5%	2.0%	39.2%	38.4%	1.00	1.99
QC	23.1%	3.6%	-4.0%	19.9%	20.7%	0.90	2.00
NB	2.2%	13.7%	-13.3%	2.1%	2.5%	1.13	2.05
NS	2.8%	16.0%	-21.3%	2.2%	2.8%	1.03	1.90
PE	0.4%	22.5%	-20.4%	0.3%	0.3%	0.75	1.86
NL	1.4%	7.4%	10.1%	1.5%	1.3%	0.97	2.25

Displays the value of selected provincial variables and initial equilibrium values.

Table 12: 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	Upstream Measure, u^j	Trade Elasticity, θ^j
Agriculture, Mining	01-14	0.63	0.014	0.128	3.202	11.92
Food, Textiles	15-19	0.33	0.050	0.089	1.789	4.56
Wood	20	0.35	0.001	0.014	2.608	10.83
Paper	21-22	0.43	0.009	0.044	2.698	9.07
Chemicals, Rubber	23-25	0.21	0.027	0.120	2.764	19.16
Metals	26-28	0.34	0.005	0.090	3.139	5.02
Equipment, Vehicles	29-35	0.26	0.086	0.197	2.204	6.19
Manufacturing, n.e.c.	36-37	0.45	0.015	0.023	1.590	5.00
Utilities	40-41	0.73	0.013	0.033	2.327	5.00
Construction	45	0.40	0.133	0.154	1.228	5.00
Wholesale and Retail	50-52	0.61	0.110	0.185	1.824	5.00
Hotels and Restaurants	55	0.49	0.037	0.048	1.477	5.00
Transport	60-63	0.50	0.017	0.060	2.601	5.00
Communication	64	0.59	0.001	0.009	2.788	5.00
Finance	65-67	0.55	0.058	0.135	2.159	5.00
Real Estate	70-71	0.78	0.114	0.147	1.442	5.00
Software	72	0.57	0.006	0.035	2.764	5.00
Other Business Services	73-74	0.66	0.005	0.072	2.789	5.00
Public Admin.	75	0.51	0.140	0.154	1.154	5.00
Education	80	0.79	0.057	0.061	1.100	5.00
Health and Social	85	0.71	0.048	0.071	1.397	5.00
Other Services	90-93	0.61	0.057	0.095	1.753	5.00

Industry data from the OECD Structural Analysis Database. The Input-Output Multiplier μ^j is the j^{th} element of $(\boldsymbol{I}-\tilde{\boldsymbol{A}})^{-1}\boldsymbol{\beta}$, where $(\boldsymbol{I}-\tilde{\boldsymbol{A}})^{-1}$ 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). The measure of upstreamness is the average number of production stages output from each sector is from final consumers; it is the row-sum of the Ghosh Inverse Matrix $(\boldsymbol{I}-\tilde{\boldsymbol{B}})^{-1}$ described in section 4.3.

Table 13: Symmetric Internal Trade Costs

	Exporter									
Importer	AB	BC	MB	NB	NL	NS	ON	PE	QC	SK
AB		86	110	176	198	188	91	269	128	89
BC	86		145	199	251	192	105	284	132	147
MB	110	145		200	196	207	105	282	145	111
NB	176	199	200		91	99	133	114	113	244
NL	198	251	196	91		111	137	186	130	317
NS	188	192	207	99	111		129	125	139	244
ON	91	105	105	133	137	129		168	74	115
PE	269	284	282	114	186	125	168		194	293
QC	128	132	145	113	130	139	74	194		168
SK	89	147	111	244	317	244	115	293	168	

Our measure of symmetric tariff-equivalent internal trade costs between all Canadian provinces, based on the Head-Ries Index of Head and Ries (2001).

Measuring Trade Costs in Canada

We adopt the Albrecht and Tombe (2016) measure of trade costs within Canada. Their results are replicated in Table 3. For added clarity, we expand upon their results to illustrate the importance of asymmetries. We also provide further evidence that asymmetries are best characterized by exporter-specific trade costs within Canada.

How large are trade costs in Canada? For a broad class of models, one can infer barriers to trade from observable data on trade flows and production, conditional on an assumption for the cost-elasticity of trade (Head and Ries, 2001; Novy, 2013). This estimate is known as a Head-Ries Index and takes the form,

$$\bar{\tau}_{ni} = \left(\frac{\tau_{ni}\tau_{in}}{\tau_{nn}\tau_{ii}}\right)^{\frac{1}{2}} = \left(\frac{x_{nn}x_{ii}}{x_{ni}x_{in}}\right)^{\frac{1}{2\theta}}, \tag{15}$$

where $\bar{\tau}_{ni}$ is the geometric-average of actual trade costs, x_{ni} is the trade flows imported by region n that originate from region i, x_{nn} is the output of region n consumed locally, and θ is the cost-elasticity of trade. Interpreting this measure is simple, as it represents what is called an *iceberg* trade cost: a producer in region i must ship τ_{ni} units of a good for one unit to arrive at the destination region n. However, the τ_{nn} terms in the denominator of equation 15 make clear that we can only measure trade costs *relative to within-region* trade costs. A value of $\bar{\tau}_{ni} > 1$ therefore implies inter-regional trade is more costly than trade within a region (say, between cities). Finally, this measure is valid whether a country's total trade balances or not. The model we develop in Section 3 features endogenous trade imbalances and the above expression holds.

To measure $\bar{\tau}_{ni}$, we require data on trade flows x_{ni} and gross output consumed locally x_{nn}. We use sectoral data on inter-provincial trade, international trade, and gross output in 2010 from

Table 14: Asymmetric Trade Cost Estimates

	Exporter									
Importer	AB	BC	MB	NB	NL	NS	ON	PE	QC	SK
AB		83	152	221	288	226	69	445	110	136
BC	89		183	278	377	245	80	518	123	197
MB	75	111		200	178	201	60	398	105	110
NB	136	136	200		78	92	62	182	76	224
NL	129	158	215	105		100	66	238	93	292
NS	154	147	213	107	122		71	192	98	264
ON	115	132	162	234	238	207		349	84	171
PE	150	139	193	63	141	73	61		89	205
QC	148	142	192	159	174	190	65	358		234
SK	51	105	112	266	343	224	70	407	115	

Our measures of asymmetric tariff-equivalent internal trade costs between all Canadian provinces. We follow Waugh (2010) and use additional price data to distinguish between the direction of trade for a given pair.

Statistics Canada's CANSIM Table 386-0003. In this section, we work only with aggregated data. In the quantitative analysis, we work with 22 sectors for which each province has at least some production. Finally, we require a value for the cost-elasticity of trade θ. We review the evidence in Section 3.3 but here we simply set $\theta = 5$. Any particular trade cost measure we present can be easily rescaled to other values.

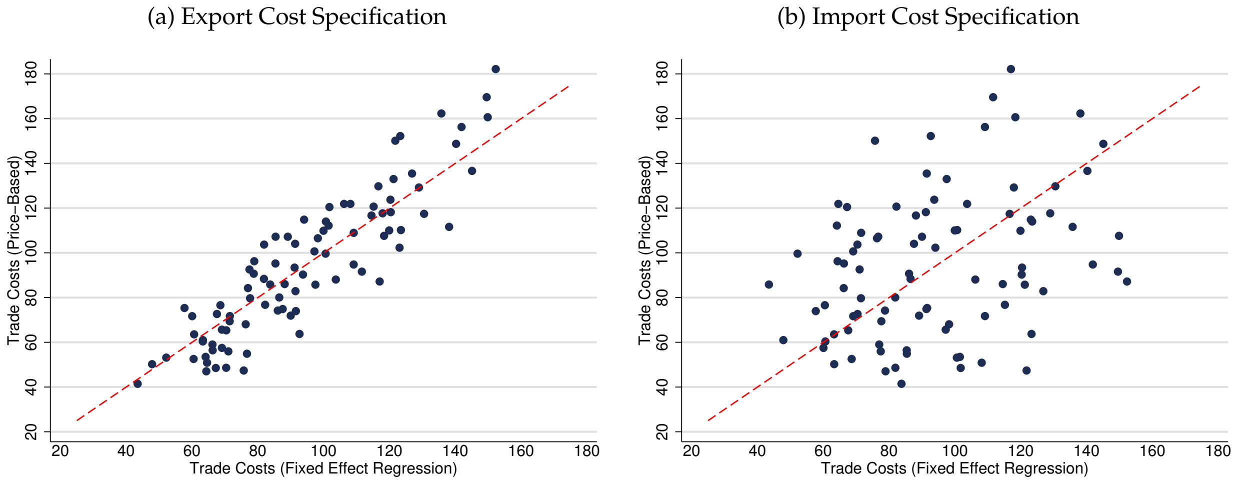
What about trade cost asymmetries? Our previous Head-Ries measure was symmetric by construction. There are two ways to measure trade cost asymmetry. First, we can use price differences between regions along with data on trade flows to infer trade costs. Second, we can infer them from fixed-effects within a standard gravity regression. Let's begin with the price-based measure. As Waugh (2010) demonstrates, from the same large class of trade models for which equation 15 holds, we have

$$\tau_{ni} = \frac{P_n}{P_i} \left(\frac{\pi_{ni}}{\pi_{ii}} \right)^{-\frac{1}{\theta}}, \tag{16}$$

where τ_{ni} is the cost for region n to import from region i, P_n is the aggregate price index in region n, and π_{ni} is the fraction of region n expenditures allocated to goods from region i. We have spatial price data for Canadian provinces through the inter-city price index constructed by Statistics Canada.[9] These are price *level* comparisons, not standard CPI price indexes. Using these data and the trade data outlined earlier, we can calculate τ_{ni} using this expression. In Table 13, we provide our estimates of $\bar{\tau}_{ni}$ and τ_{ni} for all regional pairs within Canada. For example, British

[9]We consider P_i as the simple average of the spatial price index across the following goods: alcoholic beverages, bakery and other cereal products, clothing and footwear, dairy products and eggs, fruit and vegetables, gasoline, household furnishings and equipment, meat, poultry and fish, other food, personal care supplies and equipment, purchase of passenger vehicles, and tobacco products. Our results hold very closely if we only look at the All-Items index.

Figure 3: Comparing Two Methods to Estimate Trade Costs



Displays price-based trade cost estimates from equation 16 with the fixed-effect regression estimates from equation 17. Panel (a) interprets fixed-effects results as a province-specific export cost while panel (b) interprets the fixed-effects as an import cost.

Columbia incurs a 183% tariff-equivalent cost of trade when it imports from Manitoba but the reverse flow, Manitoba's imports from British Columbia, incur only a 111% cost. Overall, poorer regions, such as the Maritime provinces, tend to display higher trade costs costs in general, and higher costs of exporting in particular, than richer regions of Canada. Importantly, the trade costs reported in Table 13 are not particular to 2010. We re-estimated these trade costs for the period 2007 through 2014 and find similar values.

An alternative way to estimate asymmetric trade costs involves a fixed-effect regression. Consider the case where trade cost asymmetries are due to additional export costs — region-specific costs that are incurred regardless of the eventual destination. To measure export costs, we follow Waugh (2010). It is straightforward to show $ln\left(\pi_{ni}/\pi_{nn}\right) = S_i - S_n - \theta ln(\tau_{ni})$, where the S terms capture region-specific factors such as productivity and factor prices. If $\tau_{ni} = D_{ni}^{\delta}\tau_i$ then

$$ln\left(\frac{\pi_{ni}}{\pi_{nn}}\right) = \delta ln(D_{ni}) + \iota_n + \eta_i + \epsilon_{ni}.$$

where $\eta_i = S_i - \theta ln(\tau_i)$ and $\iota_n = -S_n$. So, we infer the exporter specific trade costs from fixed-effect estimates $\hat{\tau}_i = e^{-\left(\hat{\eta}_i + \hat{\iota}_i\right)/\theta}$ and adjust the symmetric trade cost measure $\bar{\tau}_{ni}$ with

$$\tau_{ni} = \bar{\tau}_{ni}\sqrt{\hat{\tau}_i/\hat{\tau}_n}. \tag{17}$$

If trade cost asymmetries were the result of region-specific *import* costs, we identify them in the same way but instead $\tau_{ni} = \bar{\tau}_{ni}\sqrt{\hat{\tau}_n/\hat{\tau}_i}$.

We plot both sets of τ_{ni} estimates in Figure 3. This exercise is important, as we do not have sectoral price level data across all regions. Based on the aggregate results, the export-cost specification is a good match to the price-based estimates. We therefore use the export-cost specification to estimate trade costs for all sectors.

Incorporating Source-Based Taxes

In the main text, we quantified the aggregate productivity cost of Canada's equalization program but abstracted from the presence of provincial revenue sources not paid by residents. Source-based taxes, such as corporate taxes, resource revenues, investment income, and so on, allow a provincial government to provide public services or lower taxes to residents. And since provinces differ dramatically in their access to source-based taxes, there is an incentive for workers to migrate to capture such fiscal benefits, rather than for more fundamental considerations like productivity or amenities. This misallocates labour across provinces and lowers productivity. Equalization payments to provinces with less access to such revenue sources can, at least partially, offset this rent-seeking migration This idea was first explored by Buchanan (1950), and later in the Canadian context by Boadway and Flatters (1982) and others. Though this theoretical motivation for equalization is sound, in practice it may not improve efficiency outcomes given the many other policies that distort labour allocations. Indeed, Albouy (2012) finds just that.

To ensure our main results are not dramatically overestimating the aggregate productivity cost of equalization, we augment our main model to feature source-based taxes. Specifically, we incorporate economic rents F_n^j as an additive term within each sector's total revenue $R_n^j = \frac{w_n L_n^j}{\phi^j} + F_n^j$. This would result from a production technology that features an additive productivity term, such that the marginal product of labour is no longer proportional to the average product of labour as in a typical Cobb-Douglas technology. Aggregating across sectors within a region results in total income $I_n = w_n L_n - S_n + F_n$, where $F_n = \sum^j F_n^j$. Workers optimally choose to work in each province such that $l_n \propto \left(\left(w_n - s_n + f_n\right) \delta_n / P_n\right)^\kappa$, where s_n and f_n are the per worker values of S_n and F_n. The presence of source-based tax revenue therefore distorts the allocation of labour in the same way that other fiscal flows s_n can. In principal, f_n can offset distortions caused by s_n. To explore this possibility, we calibrate the initial value of f_n to match the sum of provincial resource revenues, investment income, and corporate income tax revenue. We then simulate the effect of eliminating equalization payments on aggregate real GDP, as in the main text. We find that instead of lowering aggregate real GDP by 0.16 per cent, it falls by 0.14 per cent. Thus, we conclude abstracting from source-based revenue sources in our primary analysis does not overly bias our results. To be sure, while exploring the interactions between trade and all the various transfer and tax arrangements is beyond the scope of this paper, it is an area potentially ripe for further investigation.

Alternative Parameter Values

Our main results are robust to alternative parameter values. First, we consider two alternatives where workers cannot migrate between provinces ($\kappa = 0$) or where they are more sensitive to income differences than our baseline model supposes ($\kappa = 3$). We display the results of the gains

Table 15: Effect of Interprovincial Transfers (Per Cent), Alternative κ Values

	No Migration ($\kappa = 0$)			Higher Migration Elasticity ($\kappa = 3$)		
Region	Real Income	Real Wages	Emp.	Real Income	Real Wages	Emp.
BC	-1.9%	-0.2%	0.0%	-1.5%	-0.1%	-4.7%
AB	-8.5%	-0.4%	0.0%	-8.2%	0.4%	-22.7%
SK	-0.7%	0.0%	0.0%	-1.0%	0.0%	-3.2%
MB	8.1%	0.6%	0.0%	6.4%	-0.6%	20.2%
ON	-0.8%	-0.1%	0.0%	-0.7%	0.1%	-2.4%
QC	3.6%	0.3%	0.0%	3.2%	-0.1%	9.5%
NB	16.6%	1.0%	0.0%	14.6%	-0.8%	50.3%
NS	20.2%	1.6%	0.0%	14.7%	-0.2%	50.4%
PE	31.3%	2.3%	0.0%	28.5%	-2.0%	111.5%
NL	7.8%	0.1%	0.0%	25.5%	-2.2%	97.2%

Displays the effect of fiscal transfers on real income, real wages, and employment for different values of the real income elasticity of migration.

from transfers analysis in Table 15. There is little difference between the two in terms of real income changes, although it is clear that more elastic migration amplifies the employment change due to fiscal transfers. They become more negative for contributor regions, and more positive for recipient regions. This matters for aggregate changes. With highly elastic migration, aggregate real GDP declines 1.5 per cent. But without a migration response, the real GDP change is nil.

Next consider alternative values for the trade elasticity θ^j. Lower values of θ^j mean a greater dispersion of productivity across varieties, and therefore larger gains from trade. We report the effect of observed fiscal transfers in Table 16. Between a small trade elasticity and large, the real income, real wage, and employment changes due to observed fiscal transfers are largely similar. The migration induced by transfers is also slightly larger with smaller values of θ^j since the real income changes are slightly larger. We also report the effect of removing asymmetric trade costs in the last three columns of Table 16. This requires we re-estimate the trade costs and changes due to trade cost asymmetries that we reported in the main text. We do not report those estimates here. Simulating the gains from removing asymmetric trade costs, we find the real wage change results depend more on the specific values for θ^j, as this parameter directly governs the gains from trade. Changes in real income and employment are less sensitive. The aggregate real GDP gains from removing trade cost asymmetries ranges from a low of 2.6 per cent if $\theta = 8$ to a high of 6.9 per cent if $\theta = 3$.

Our final robustness exercise concerns the degree of fiscal integration, ζ. This parameter does not affect the results concerning the effect of observed transfers. When we remove both income-sensitive and exogenous transfers, we simply set $T_n = 0$ and ζ plays no role. In the experiments involving removal of income-sensitive transfers, the effect on each province's real income will be tied directly to ζ by construction. Here, we explore how the results of changing trade costs depend on whether ζ is higher or lower than we calibrate. Changing trade costs affects income,

Table 16: Effect of Interprovincial Transfers and Trade Costs (Per Cent), Alternative θ Values

	Effect of Observed Transfers			Removing Asymmetric Trade Costs		
Region	Real Income	Real Wages	Employment	Real Income	Real Wages	Employment
Uniform Trade Elasticity ($\theta^j = 5$ for all j)						
BC	-1.7%	-0.1%	-2.9%	3.5%	3.3%	-0.7%
AB	-8.3%	0.1%	-12.5%	3.9%	3.0%	-0.2%
SK	-0.9%	0.0%	-1.7%	5.9%	12.6%	2.8%
MB	7.2%	-0.1%	10.6%	5.0%	6.7%	1.5%
ON	-0.8%	0.0%	-1.5%	4.8%	3.3%	1.2%
QC	3.4%	0.1%	4.8%	2.6%	3.3%	-2.0%
NB	15.6%	0.1%	23.9%	3.6%	9.3%	-0.6%
NS	17.3%	0.8%	26.6%	2.6%	7.8%	-2.0%
PE	29.8%	0.2%	47.3%	7.7%	17.7%	5.4%
NL	10.1%	-0.3%	15.2%	4.7%	7.2%	1.0%
High Trade Elasticity ($\theta^j = 8$ for all j)						
BC	-1.7%	-0.1%	-2.8%	2.2%	2.1%	-0.5%
AB	-8.3%	0.0%	-12.5%	2.4%	1.8%	-0.1%
SK	-0.9%	0.0%	-1.6%	4.0%	8.5%	2.2%
MB	7.2%	-0.1%	10.6%	3.2%	4.3%	1.0%
ON	-0.8%	0.0%	-1.5%	3.0%	2.0%	0.7%
QC	3.4%	0.1%	4.7%	1.7%	2.1%	-1.2%
NB	15.6%	0.1%	23.8%	2.3%	6.2%	-0.3%
NS	17.1%	0.6%	26.3%	1.7%	5.1%	-1.2%
PE	29.7%	0.1%	47.2%	5.1%	11.9%	3.9%
NL	10.4%	-0.2%	15.5%	3.2%	4.8%	1.0%
Low Trade Elasticity ($\theta^j = 3$ for all j)						
BC	-1.7%	-0.2%	-3.0%	5.8%	5.5%	-1.3%
AB	-8.3%	0.1%	-12.5%	6.6%	5.2%	-0.2%
BC	-1.7%	-0.2%	-3.0%	5.8%	5.5%	-1.3%
MB	7.2%	-0.1%	10.5%	8.4%	10.8%	2.3%
ON	-0.8%	0.0%	-1.5%	8.3%	5.9%	2.3%
QC	3.4%	0.1%	4.8%	4.3%	5.3%	-3.4%
NB	15.7%	0.2%	23.9%	5.9%	14.3%	-1.2%
NS	17.6%	1.2%	27.1%	4.3%	11.9%	-3.3%
PE	29.9%	0.3%	47.5%	11.9%	26.8%	7.4%
NL	9.9%	-0.5%	14.7%	7.1%	11.0%	0.6%

Displays the effect of fiscal transfers and asymmetric trade costs on real income, real wages, and employment.

and therefore affects transfers. In particular, given the discussion in the main text, the stronger the sensitivity of transfers to income, the smaller the gains from lowering trade cost asymmetries will

Table 17: Gains from Lower Internal Trade Costs (Per Cent)

	Asymmetric Costs			Non-Distance Costs		
	Real Income	Real Wages	Emp.	Real Income	Real Wages	Emp.
Lower Degree of Fiscal Integration ($\zeta = 0.2$)						
BC	2.7	2.7	-0.7	4.8	4.6	-2.5
AB	2.9	2.5	-0.3	6.3	6.0	-0.3
SK	6.1	8.2	4.3	16.6	16.1	14.4
MB	3.8	4.9	1.0	7.7	7.7	1.6
ON	3.7	2.9	0.7	3.9	3.8	-3.8
QC	2.1	2.5	-1.5	6.9	7.0	0.5
NB	3.7	7.2	0.8	19.7	24.5	19.1
NS	2.7	6.3	-0.6	14.6	19.6	11.5
PE	7.6	15.2	6.5	23.1	29.2	24.2
NL	4.4	4.9	1.8	24.8	22.5	26.8
Higher Degree of Fiscal Integration ($\zeta = 0.4$)						
BC	2.8	2.7	-0.6	4.9	4.6	-2.3
AB	3.2	2.5	-0.1	6.4	6.0	-0.3
SK	2.8	8.4	-0.6	15.5	16.2	12.9
MB	3.4	4.9	0.3	8.0	7.7	2.1
ON	4.4	2.9	1.7	3.9	3.8	-3.7
QC	1.8	2.5	-2.0	7.0	7.0	0.6
NB	2.3	7.3	-1.3	18.9	24.6	17.9
NS	1.7	6.3	-2.2	14.2	19.6	11.0
PE	5.7	15.3	3.6	24.4	28.9	26.2
NL	2.5	5.1	-1.0	24.0	22.5	25.5

Displays the effect on real income, real wages and employment from lowering various measures of internal trade costs using different levels of the fiscal integration parameter ζ.

be for poor regions. In Table 17 we report our results for both a lower and a higher value for ζ.

Solving for the Initial and Counterfactual Equilibrium

To solve the model, it is helpful conceptually (and computationally) to build on the long history of input-output economics. Following these models, the following proposition provides a simple way to solve for equilibrium wages, given trade shares.

Proposition 3 *Given trade shares π^j_{ni}, the equilibrium revenue of all sectors in all regions solves*

$$\mathbf{R} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}, \tag{18}$$

where $\mathbf{R}$ is the $NJ \times 1$ vector of sectoral revenue. It stacks the $J \times 1$ vectors $\mathbf{R_n}$ with elements R^j_n.

The matrix $\mathbf{A}$ is the $NJ \times NJ$ global input coefficient matrix

$$\mathbf{A} = \begin{bmatrix} \mathbf{A_{11}} & \cdots & \mathbf{A_{N1}} \\ \vdots & \ddots & \vdots \\ \mathbf{A_{1N}} & \cdots & \mathbf{A_{NN}} \end{bmatrix}, \tag{19}$$

with elements $\mathbf{A_{ni}}$ as the $J \times J$ input coefficient matrix, with elements $\gamma^{kj}(1-\phi^k)\pi^j_{ni}$ for the j^{th} row and k^{th} column. The vector $\mathbf{F}$ the $NJ \times 1$ vector of final demands with elements $\sum_i \alpha^j I_i \pi^j_{in}$ for the row indexed $j + J \times (n-1)$. That is, $\mathbf{F}$ simply stacks the $J \times 1$ vectors $\mathbf{F_n}$ with elements $\sum_i \alpha^j I_i \pi^j_{in}$.

Proof: See proofs of propositions later in the appendix.

Equation 18 is a familiar expression in any input-output model. The key difference is that in our setup the input coefficients are endogenous and solved in full general equilibrium. They react to changes in productivity, trade costs, input prices, or fiscal transfers. Importantly, Proposition 3 allows us to solve for equilibrium wages as a function of trade shares. The vector **F** represents global spending on final goods from each region and sector. It depends only on wages, employment, and trade flows. The matrix of global input coefficients matrix **A** depends only on trade shares. Finally, a vector of sales **R** implies wages in each region, since $w_n = \sum_j \phi^j R^j_n / L_n$. All together, this is a system of equations that solves N equilibrium wages given trade shares π^j_{ni}.

If our goal was to estimate equilibrium wages and incomes consistent with observed trade shares from data, we would be done (and we would have learned little). Instead, our goal is to estimate counterfactual responses to policy changes — namely, fiscal transfers or changes in trade costs. Conveniently, there is a simple yet powerful method to solve these counterfactual responses. It is known as the Exact-Hat Algebra approach of Dekle et al. (2007). Specifically, consider moving from an initial equilibrium consistent with data to a new counterfactual equilibrium. Denote the equilibrium change in all variables as $\hat{x} = x'/x$, we can write the changes in equations 3 to 5 as

$$\hat{c}_n^j = \hat{w}_n^{\phi^j} \prod_{k=1}^{J} \left(\hat{P}_n^k\right)^{\gamma^{jk}(1-\phi^j)}, \tag{20}$$

$$\hat{\pi}_{ni}^j = \left(\hat{\tau}_{ni}^j \hat{c}_i^j / \hat{P}_n^j\right)^{-\theta^j}, \tag{21}$$

$$\hat{P}_n^j = \left[\sum_{i=1}^{N+1} \pi_{ni}^j \left(\hat{\tau}_{ni}^j \hat{c}_i^j\right)^{-\theta^j}\right]^{-1/\theta^j}. \tag{22}$$

Equations 20 to 22 define a system $\hat{\boldsymbol{\pi}} = f(\mathbf{w}; \hat{\boldsymbol{\tau}})$, which maps wage changes, given trade cost changes, to trade share changes. With counterfactual trade shares $\pi_{ni}^{j\,\prime} = \pi_{ni}^j \hat{\pi}_{ni}^j$, proposition 3 gives counterfactual sales and wages. The equilibrium wage changes solve this system, taking the initial trade shares π_{ni}^j as given. So, with Proposition 3 together with equations 20 to 22 we can solve the equilibrium response to any change to trade costs (τ_{ni}^j) or fiscal integration (ζ), all from an initial equilibrium that exactly matches trade data. Trade imbalances also change in any counterfactual equilibrium. Some of the imbalances are exogenous $\bar{S}_n$ while others are due to fiscal transfers, and therefore $S_n' = (1 - t_n')w_n' L_n' + \bar{S}_n$.

Equilibrium changes in the distribution of employment can be similarly solved in terms of relative changes. From equation 8, and given changes in per capita real income $\hat{m}_n/\hat{P}_n$, the counterfactual share of national employment in province-n is

$$l_n' = \frac{l_n \left(\hat{m}_n/\hat{P}_n\right)^{\kappa}}{\sum_{i=1}^{N} l_i \left(\hat{m}_i/\hat{P}_i\right)^{\kappa}}. \tag{23}$$

Notice $\hat{l}_n \propto \left(\hat{m}_n/\hat{P}_n\right)^{\kappa}$, and therefore κ is simply the real income elasticity of migration. There are good estimates of this available, which simplify the model calibration.

Our key outcomes of interest are real income and real wages for all regions and sectors. For a given sector, real value-added is simply total value-added divided by the price index $w_n L_n^j / P_n^j$, so real wages (real value-added per worker) are simply w_n / P_n^j. For aggregate labour productivity, we look at overall real wages w_n/P_n in region n. This is simply a region's total value-added per worker $\sum_{j=1}^{n} w_n L_n^j / L_n = w_n$, deflated by the aggregate price index P_n. Finally, real income is $I_n / L_n P_n$.

The link between trade changes and real wage changes is particularly informative. Proposition 2 of Albrecht and Tombe (2016) provides a convenient and compact expression for equilibrium real wage changes. We do not reproduce the proof here, but the intuition is straightforward. In a standard Eaton-Kortum model without input-output relationships, log real wage changes depend on changes in the home share of spending $\hat{\pi}_{nn}^j$. Specifically, equations 20 and 21 with $\phi^j = 1$ for all j implies $log(\hat{w}_n/\hat{P}_n^j) = -log(\hat{\pi}_{nn}^j)/\theta^j$. Collect these changes into a $J \times N$ matrix $\mathbf{G}$. With input-output relationships, we can simply transform $\mathbf{G}$ according to

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

where $(\mathbf{I}-\tilde{\mathbf{A}})^{-1}$ is the $J \times J$ Leontief Inverse Matrix, where the input matrix $\tilde{\mathbf{A}}$ has elements $\gamma^{kj}(1-\phi^k)$.[10] The matrix $\tilde{\mathbf{G}}$ is the $J \times N$ matrix of equilibrium real wage changes for all sectors given $\hat{\pi}_{nn}^j$. Next, with a slight abuse of notation, collect aggregate real wage changes in each province into a vector $\hat{\mathbf{y}}$ with elements $\hat{w}_n/\hat{P}_n$. This is simply

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

where $\boldsymbol{\beta}$ is a $J \times 1$ vector with elements β^j. With these aggregate real wage changes, the real income of a worker in region n is

$$\hat{U}_n = \left(\hat{m}_n/\hat{P}_n\right),$$

where $\hat{m}_n = \hat{I}_n/\hat{L}_n$ and $\hat{I}_n = \frac{w_n' L_n' - S_n'}{w_n L_n - S_n}$.

What do these expressions mean in plain language? The $J \times 1$ vector $(\mathbf{I}-\tilde{\mathbf{A}})^{-1}\boldsymbol{\beta}$ is a very straightforward measure of a sector's "influence" on an economy. A sector may be extremely valuable as an input supplier to many other sectors, so productivity shocks in that sector cascade throughout the economy. Recent research by Acemoglu et al. (2012), Jones (2013), and Carvalho and Gabaix (2013) all show in closed-economy settings that this vector collects the elasticities of aggregate output with respect to sectoral productivity. In our setting, this vector represents by how much standard gains from trade $\mathbf{G}$ are amplified by input-output linkages. We refer to $(\mathbf{I}-\tilde{\mathbf{A}})^{-1}\boldsymbol{\beta}$ as the vector of *input-output multipliers*, though they should not be confused with multipliers from classic input-output analysis. The linkages are very important for our quantitative results, and also for our qualitative results regarding the distribution of economic activity across sectors and regions.

Changes in provincial real wages and employment map naturally to changes in Canada's overall real GDP. Given provincial real wage changes $\hat{y}_n = \hat{w}_n/\hat{P}_n$ and employment changes $\hat{l}_n$, the change in national real GDP is

$$\hat{Y} = \sum_{i=1}^{N} \omega_n \hat{y}_n \hat{l}_n, \tag{24}$$

where ω_n is province n's initial share of national real GDP.

[10] The tilde distinguishes this matrix from the *global* input coefficient matrix $\mathbf{A}$ defined earlier.

Proofs of Propositions

Proposition 1

Define $t_n = Bw_n^{\zeta}$ and find the term B such that the central government budget balances. The government budget balances if $\sum_{n=1}^{N}(t_n - 1)w_n L_n = 0$ and therefore

$$\begin{aligned}
\sum_{n=1}^{N} w_n L_n &= \sum_{n=1}^{N} t_n w_n L_n, \\
&= B \sum_{n=1}^{N} w_n^{\zeta} w_n L_n, \\
\Rightarrow \quad B^{-1} &= \sum_{n=1}^{N} w_n^{\zeta} \left(\frac{w_n L_n}{\sum_{n=1}^{N} w_n L_n} \right).
\end{aligned}$$

Raising each side to the power $1/\zeta$, we have $B^{-1/\zeta} = \left[\sum_{n=1}^{N} w_n^{\zeta} \left(\frac{w_n L_n}{\sum_{n=1}^{N} w_n L_n} \right) \right]^{1/\zeta} \equiv \bar{w}$. Plug this into the initial definition of t_n to yield our result

$$\begin{aligned}
t_n &= Bw_n^{\zeta}, \\
&= \left(w_n / B^{-1/\zeta} \right)^{\zeta}, \\
&= (w_n/\bar{w})^{\zeta}. \blacksquare
\end{aligned}$$

Proposition 2

Workers choose their province of residence to maximize their utility. Real income and their unique location preferences both matter. Specifically, a worker chooses province-n if $t_n w_n z_n / P_n > \max_{k \neq n} \{t_k w_k z_k / P_k\}$. If location preferences z_n are independently and identically distributed Frechet with CDF $F_n(x) = e^{-(x/\delta_n)^{-\kappa}}$, where κ governs the variation of location preference across workers and δ_n is the common valuation, the share of workers choosing province-n is

$$l_n = Pr\left(t_n w_n z_n / P_n > \max_{k \neq n} \{t_k w_k z_k / P_k\} \right).$$

Consider both sides of the inequality separately. The left side is distributed according to

$$\begin{aligned} Pr\left(\frac{t_n w_n z_n}{P_n} < x\right) &= Pr\left(\frac{t_n w_n z_n}{P_n} < x\right), \\ &= Pr\left(z_n < \frac{P_n}{t_n w_n} x\right), \\ &= exp\left\{-\left(\frac{P_n}{t_n w_n \delta_n} x\right)^{-\kappa}\right\}, \\ &= exp\left\{-\left(x/\phi_n\right)^{-\kappa}\right\}, \end{aligned}$$

where $\phi_n = t_n w_n \delta_n / P_n$. The third line follows from the Frechet distribution of worker location preferences z_n.

Turning to the right side, the probability that all other regions k have a value below x is

$$\begin{aligned} Pr\left(\max_{k\neq n}\{t_k w_k z_k/P_k\} < x\right) &= \prod_{k\neq n} Pr\left(t_k w_k z_k/P_k < x\right), \\ &= \prod_{k\neq n} Pr\left(z_k < \frac{P_k}{t_k w_k} x\right), \\ &= \prod_{k\neq n} exp\left\{-\left(\frac{P_k}{t_k w_k \delta_k} x\right)^{-\kappa}\right\}, \\ &= exp\left\{-x^{-\kappa}\sum_{k\neq n}\left(\frac{P_k}{t_k w_k \delta_k}\right)^{-\kappa}\right\}, \\ &= exp\left\{-\left(x/\Phi_n\right)^{-\kappa}\right\} \end{aligned}$$

which is also Frechet but with location parameter $\Phi_n = \left(\sum_{k\neq n}\left(t_k w_k \delta_k/P_k\right)^{\kappa}\right)^{1/\kappa}$. The share of workers in province-n is therefore just the probability that one Frechet-distributed random variable is smaller than another. This has a simple solution. If X and Y are both independently distributed Frechet random variables with location parameters a and b, respectively, and variance parameter κ then $Pr\left(X \geq Y\right) = \frac{b^{\kappa}}{a^{\kappa}+b^{\kappa}}$. This follows from a standard property of exponential distributions, and the fact that if X is Frechet with parameter a then $X^{-1/\kappa}$ is exponential with parameter a^{κ}. Thus,

$$\begin{aligned} l_n &= 1 - \frac{\Phi_n^{\kappa}}{\phi_n^{\kappa} + \Phi_n^{\kappa}}, \\ &= \frac{\left(t_n w_n \delta_n / P_n\right)^{\kappa}}{\sum_{k=1}^{N}\left(t_k w_k \delta_k / P_k\right)^{\kappa}}, \end{aligned}$$

which is our result. ■

Proposition 3

Total sales in region n and sector j equals total spending from all other regions, $R_n^j = \sum_{i=1}^N \pi_{in}^j X_i^j$. Total spending includes spending on both final goods intermediate inputs, $X_n^j = \alpha^j I_n + \sum_{k=1}^J \gamma^{kj}(1-\phi^k)R_n^k$. Together, we have $R_n^j = \sum_{i=1}^N \pi_{in}^j \alpha^j I_i + \sum_{i=1}^N \sum_{k=1}^J \pi_{in}^j \gamma^{kj}(1-\phi^k)R_i^k$. It is helpful to write these expressions in matrix form. Define $\mathbf{A_{ni}}$ as the $J \times J$ input coefficient matrix, with elements $\gamma^{kj}(1-\phi^k)\pi_{ni}^j$ for the j^{th} row and k^{th} column. Now, form the $NJ \times NJ$ matrix

$$\mathbf{A} = \begin{bmatrix} \mathbf{A_{11}} & \cdots & \mathbf{A_{N1}} \\ \vdots & \ddots & \vdots \\ \mathbf{A_{1N}} & \cdots & \mathbf{A_{NN}} \end{bmatrix}.$$

Call this matrix the *global input coefficient matrix*.

Next, define global demand as the $NJ \times 1$ vector $\mathbf{F}$ with elements $\sum_i \alpha^j I_i \pi_{in}^j$ for the row indexed $j + J \times (n-1)$. This represents global spending on final goods from each region and sector. In particular, stack the $J \times 1$ vectors $\mathbf{F_n}$ with elements $\sum_i \alpha^j I_i \pi_{in}^j$, which is global demand for final goods from each of region n's sectors. With given wages, employment, and trade flows we know income from $I_n = w_n L_n - S_n$. Given the matrix of global input coefficients $\mathbf{A}$ and the vector of final demand $\mathbf{F}$, total revenue for each region and sector is the $NJ \times 1$ vector

$$\mathbf{R} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}.$$

This is a familiar expression in any input-output model. Given the vector of region-sector sales $\mathbf{R}$, we know implied wages in each region, since $w_n = \sum_j \phi^j R_n^j / L_n$. So, the set of N equilibrium wages is the solution to these equations. ■