

What's Inside Counts: Migration, Taxes, and the Internal Gains from Trade

Trevor Tombe
University of Calgary

Jennifer Winter
University of Calgary

This Version: April 2014

Abstract

Like trade between countries, trade within countries is costly; unlike between countries, gains from trade within countries depend on migration and taxes, as gains through higher wages have tax consequences that gains through lower prices do not. We confirm the first point and flexibly measure large trade costs within Canada, China, and the United States. We further measure trade cost asymmetries to gauge the importance of non-geographic factors and find they are also large. To quantify the second point, we develop a model of trade featuring within-country factor mobility and, new to the literature, central government taxes and transfers. Taxes endogenously generate unbalanced internal trade and allow the model to match trade and income data well. We find (1) substantial gains from lowering internal trade costs and (2) gains to poor regions are particularly large, amplified by internal taxes and transfers.

JEL Classification: F1, F4, R1

Keywords: Internal trade; gains from trade; migration; income taxes

Tombe (Corresponding Author): Assistant Professor, Department of Economics, University of Calgary, 2500 University Drive NW, Calgary, Alberta, T2N1N4. Email: ttombe@ucalgary.ca. Phone: 1-403-220-8068. Winter: Research Associate, The School of Public Policy, University of Calgary. Email: jwinter@ucalgary.ca. We greatly benefited from comments and suggestions made by an anonymous referee and by Azim Essaji, various conference participants at the SED Annual Meeting 2012, MidWest Macro 2012, CEA Annual Meeting 2012, 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 (though an Insight Development Grant and an Institutional Grant to Wilfrid Laurier University).

1 Introduction

Research consistently finds openness to international trade increases aggregate productivity and welfare. Less clear are how gains from trade are distributed spatially within a country and whether the gains from internal trade are similar. For a broad class of models, a sufficient statistic for aggregate gains is the share of goods and services purchased domestically (Arkolakis et al., 2012). We will show this result does not hold internally due to labour mobility and central government tax policies. Internal trade is also subject to costs that inhibit many gains from being realized. Using data for Canada, China, and the United States, we measure internal trade costs and show they are large, especially for poor regions. To quantify the consequences of these costs, we present and simulate a model that incorporates key features that are important for an internal within-country analysis.

There are two primary factors that influence trade patterns and gains from trade within a country. First, labour is mobile and responds to changes in regional incomes and living costs. The implications of this are studied recently by Redding (2012), upon whose work we build. Second, central government income taxes are levied on nominal, not real, incomes. As changes in income has tax implications while changes in living costs do not, tax policy matters for the spatial distribution of the gains from trade. This can also be relevant internationally, as European Union fiscal policies are increasingly integrated. Our model cleanly decomposes the gains from trade into gains from market access (the classic gains from trade), labour migration, and internal tax-and-transfers (which we call fiscal adjustments). Through numerous quantitative exercises, we show that fiscal adjustments are *quantitatively* important for evaluating the gains from trade liberalization.

Fiscal adjustments not only influence internal gains from trade, but also the pattern of internal trade. Albouy (2009) shows US federal taxes disproportionately burden areas with above-average incomes and are not compensated for by federal expenditures. The implication: a region that pays less taxes than it receives in transfers can sustain a trade deficit, while a region in the reverse situation will have a surplus. With taxes levied on nominal incomes, poor regions will tend to have trade deficits. In panel (a) of Figure 1a, we plot the ratio of deficits to total expenditures. For many regions, these deficits are substantial – on the order of 10% of expenditures. For Canada and China, deficits decline strongly with regional income. For the United States, deficits still decline with income, though less strongly. We use these data directly in our quantitative exercises to discipline the calibration of tax rates in each country. We find that the tax rates that match the pattern of regional deficits are very close to each country’s average tax revenue share of GDP.

What is the scope for internal trade liberalization? We estimate internal trade costs using a flexible approach that holds for a broad class of trade models following Head and Ries (2001) and Novy (2013). To our knowledge, no one has applied this measure to internal trade between sub-national regions across multiple countries.¹ Intuitively, the less a region trades with another,

¹We fit closely with other applications of this method to internal data, including Caliendo et al. (2013) and Wong (2012), though our focus differs.

relative to what it buys from itself, the higher the trade costs that we infer. This measure can (and largely does) reflect geographic factors, such as distance, between trading partners. To estimate more policy-relevant trade costs, we look at differences in trade costs that depend on the *direction of trade*. We measure trade cost asymmetries by combining the Head-Ries-Novy approach with that of [Waugh \(2010\)](#). We demonstrate using province-level spatial price levels for Canada that [Waugh \(2010\)](#)'s exporter-cost specification applies as well within countries as it does internationally. We provide more detail in Section 2.2.

Overall, we find large internal trade costs. Weighted by trade flows, tariff-equivalent internal trade costs are over 100% in Canada, 130% in the United States, and 140% in China, although these results depend on the cost-elasticity of trade. Consistent with international evidence, internal trade costs are declining with regional income, especially costs that are specific to the exporting region. These costs are not fully accounted for by observable components of trade costs, such as distance. Our measure of trade cost asymmetries reveals that poor regions within countries face significantly larger costs of *exporting* than do rich regions. For example, Ontario can export 36% cheaper than the average province while PEI faces 81% higher costs. The variation in import costs are nil.

To gauge the welfare and distributional consequences of these barriers, we must put more structure on the data. Our model is, at its core, an [Eaton and Kortum \(2002\)](#) trade model, solved through the approach of [Dekle, Eaton and Kortum \(2007\)](#), and expanded to allow regions within a country to differ in productive efficiency and to trade with each other and the world. As in [Redding \(2012\)](#), labour can freely migrate within a country. Land is fixed and serves as a congestant that allows for a non-degenerate regional distribution of labour in equilibrium. We also incorporate a non-tradable services sector along the lines of [Alvarez and Lucas \(2007\)](#). Our main model contribution is incorporating fiscal adjustments: taxes and lump-sum transfers. With this model, we find lowering measured internal trade costs by 10% increases welfare in Canada, the US, and China by 0.4%, 0.9%, and 1.3%, respectively. Fiscal adjustments account for much of these gains. For the poorest quartile of regions, this channel alone accounts for three-quarters, one-third, and one-sixth of overall gains, respectively.

Investigating the internal/spatial distribution of gains from trade is a recent and growing area of research. The most directly related to our paper is [Redding \(2012\)](#), who demonstrates that labour migration responses to trade liberalization are a quantitatively important determinant of the regional gains from trade. For primarily theoretical treatments, see [Cosar and Fajgelbaum \(2012\)](#) or [Allen and Arkolakis \(2013\)](#); for an empirical treatment, see [Atkin and Donaldson \(2013\)](#). For migration, [McCaig and Pavcnik \(2012\)](#) find trade liberalization between the US and Vietnam results in large labour movements towards coastal manufacturing centers in Vietnam. Trade and internal migration flows are also linked by [Aguayo-Tellez and Muendler \(2009\)](#) and [Hering and Paillacar \(2012\)](#) for Brazil. We go beyond these papers by systematically measuring and examining internal trade costs for multiple countries and by including an internal tax and transfer system, which is known to be important for migration decisions ([Albouy, 2009](#)). We derive clean expres-

sions for the gains from trade and quantify the effect of lower internal trade costs through various model simulations.

We are far from the first to measure internal trade costs. Most existing estimates are based on gravity models, including: [Wolf \(2000\)](#) and [Hillberry and Hummels \(2003\)](#) for the United States; [Nitsch \(2000\)](#) and [Chen \(2004\)](#) for the European Union; and [Poncet \(2005\)](#) for China. These estimates provide a single number summarizing the magnitude of internal trade costs; ours, to which we turn next, are for all regional pairs. Important components of internal trade costs, however, are not policy-relevant and involve geographic characteristics, such as distance. Shedding light on how and why distance matters for trade, [Hillberry and Hummels \(2008\)](#) exploit detail, establishment and ZIP-code-level shipment data to reveal substantial distance effects. The number of shipments within 200 miles is an order of magnitude smaller than the number within 1 mile, for example. Most importantly, they show state-level border effects are an artifact of geographic aggregation. We take these results seriously and will focus on policy-relevant trade costs.

More recently, [Agnosteva, Anderson and Yotov \(2014\)](#) develop a new method to measure internal trade costs and apply their method to Canadian data. While they find distance is the primary component, and contiguity of regions matters little, there are non-trivial unexplained trade barriers. Unexplained trade costs for Quebec with the rest of Canada, for example, is approximately 15%. We take a different approach to quantify the non-distance component of trade costs: we measure of trade cost asymmetries between regions. That is, costs associated with geography will affect trade from New York to California in the same way as trade from California to New York. Any differences in trade costs that depend on the direction of trade are more likely related caused by policy differences than common (geographic) factors between regions. With this literature in mind, we now turn to our measure of internal trade costs.

2 What's Inside that Counts?

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 outright bans on cross-border sales of health insurance. For Canada, [Beaulieu et al. \(2003\)](#) provides an anecdotal review of inter-provincial trade barriers, covering province-specific occupational licenses, home-biased government procurement, or local marketing boards for agricultural goods.

While these examples are illustrative, we can go beyond anecdotal evidence and systematically quantify the extent of trade frictions by placing a little structure on the data. These measures will prove useful in comparing trade barriers across countries and across regions within countries. They will also form the basis of the counterfactual simulations to come.

2.1 A Flexible Measure of Trade Costs

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). In these models, the product of trade in both directions between two regions relative to their local purchases is a function only of trade costs (t_{ij}) and the elasticity of trade (θ). That is, $\frac{x_{ij}x_{ji}}{x_{ii}x_{jj}} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^\theta$ and therefore

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

where $\bar{\tau}_{ij}$ is the geometric-average trade cost, x_{ij} is the trade to region i from j , x_{ii} is the output of region i consumed locally, and θ is the cost-elasticity of trade. For $i = j$, $\bar{\tau}_{ij} = 0$, which means this measure of trade costs reflects the cost of trade *over and above* any internal distribution costs for each region. It only measures the between-region component of trade costs; that is, the border cost. To measure $\bar{\tau}_{ij}$, we require data on trade flows x_{ij} and gross output consumed locally x_{ii} . Importantly, this measure applies equally well whether a country's total trade balances or not. The model we develop in Section 3 features endogenous trade imbalances and the above expression will hold.

To ensure our results are robust, we use data for three countries: Canada, the United States, and China. The years differ but are the most recent years for which we have data. For Canada, we use data from 2005 on inter-provincial and international trade data provided by Statistics Canada in CANSIM Table 386-0002 and gross output data by province from Table 386-0001. For the United States, we use the 2007 Commodity Flow Survey and data on state GDP from the Bureau of Economic Analysis.² Finally, for China, we use the Regional Input-Output data for 2002, which provides for gross output of each province and trade flows between each pair of provinces with each other and with the rest of the world. The trade flow data in these sources is taken as given and we infer locally consumed output as gross output less exports plus imports.

Finally, we require a value for the cost-elasticity of trade θ . We review evidence in Section 4.3 but here we simply set $\theta = 5$, consistent with the measurements of Simonovska and Waugh (2011) and Parro (2013). Any particular trade cost measure we present can be easily rescaled to other values.

2.1.1 Our Estimates

It is not practical to display all values of trade costs for all regional pairs. For example, there are 1,225 unique pairs of states in the United States. Instead, Figure 1 presents the results in various ways. In panel (b) we display the histogram of all bilateral cost measures for all possible pairs.

²State-level gross output is not available here for the United States, so we assume a gross output to value-added ratio of 2.5, consistent with aggregate evidence we present later in Section 4.3. Gross output data is available for Canada and China.

We exclude Hawaii and Alaska from the United States measures displayed here as they are, by far, outliers relative to the lower 48 states. Weighted by trade flows, tariff-equivalent internal trade costs are over 100% in Canada, 130% in the United States, and 140% in China.³ These results imply internal trade costs are of the same order of magnitude, although slightly smaller than, most measures of international trade costs, such as the 170% of [Anderson and van Wincoop \(2004\)](#).

Comparing regions within each country, we find trade costs decrease with per-capita GDP. We illustrate this in panel (c) of [Figure 1](#). That trade costs decrease with income is also a strong feature of the cross-country evidence for international trade costs. In the next section, we measure a more policy-relevant aspect of trade costs — that of trade cost asymmetries, which do not depend on common geographic characteristics (such as distance) for a trading pair.

2.2 Asymmetric Internal Trade Costs

Is Quebec more restrictive than Ontario for trade between these two provinces? Unfortunately, $\bar{\tau}_{ij} = \bar{\tau}_{ji}$ 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. As [Vaugh \(2010\)](#) demonstrates, the same large class of trade models for which the [Novy \(2013\)](#) results hold,

$$\tau_{ij} = \frac{P_i}{P_j} \left(\frac{\pi_{ij}}{\pi_{jj}} \right)^{-\frac{1}{\theta}}, \quad (2)$$

where τ_{ij} is the cost for region i to import from region j , P_i is the aggregate price in region i , and π_{ij} is the fraction of region i expenditures allocated to goods from region j . While we do not have spatial prices for tradable goods for all regions of each country, we do have them for Canadian provinces through the inter-city CPI index constructed by Statistics Canada.⁴ Using these price data and the trade data outlined earlier, we can calculate τ_{ij} using this expression.

We find overall average trade costs calculated with trade and price data extremely similar to those calculated from the [Novy \(2013\)](#) method, lending support to the appropriateness of the price data. The interesting deviations, however, are in determining the asymmetries in the trade costs. In [Table 1](#), we provide our estimates of $\bar{\tau}_{ij}$ and τ_{ij} for all regional pairs within Canada. Overall, it is clear that the poorer regions of Canada display higher export costs than the richer regions. For example, British Columbia incurs a 204% tariff-equivalent cost of trade when it imports from Manitoba but the reverse flow, Manitoba's imports from British Columbia, incur only a 115% cost. More systematically, regressing $\ln(\tau_{ij})$ on the exporter's real GDP/capita relative to the importer's ($\ln(y_j/y_i)$) yields a precisely estimated coefficient of -0.55. That is, internal trade costs

³These results are fully consistent with [Agnosteva et al. \(2014\)](#) for Canada and slightly higher than [Poncet \(2005\)](#) for China. [Poncet \(2005\)](#) reports tariff-equivalent internal trade costs of 53% in 1997 but uses a different cost-elasticity of trade. Rescaling her results to match the elasticity assumed in this paper, her result is 97% for China. Her measure also removes the distance effect.

⁴We 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.

are decreasing with an exporter's real GDP/capita. This is the same result found by [Waugh \(2010\)](#) internationally.

We can more precisely estimate the magnitude of the export costs. First, consider distance as the only bilateral component of trade costs between two regions, with the remaining costs being either importer- or exporter-specific: $\tau_{ij} \propto D_{ij}^\delta \tau_i^m \tau_j^e$, where δ is the distance-elasticity of trade costs and τ_i^m and τ_j^e are the importer- and exporter-specific trade costs. Regress our asymmetric measure of trade costs from equation 2 on the log distance between regions i and j (how we measure distance is described in the appendix) and a set of importer and exporter fixed effects, denoted ι_i and η_j respectively,

$$\ln(\tau_{ij}) = \delta \ln(D_{ij}) + \iota_i + \eta_j + \epsilon_{ij}.$$

The trade costs of the fixed effects can be measured as $\hat{\tau}_i^m = 100 \cdot [\exp(\hat{\iota}_i) - 1]$ and $\hat{\tau}_j^e = 100 \cdot [\exp(\hat{\eta}_j) - 1]$. We report the results of this regression in the first column of Table 2. The distance-elasticity of 0.25 — consistent the elasticity of freight costs to distance from [Hummels \(2001\)](#). Using the fixed effects, we calculate the export and import trade costs from the fixed effects and provide them in panel (b) of the table. Ontario can export 36% cheaper than the average province while PEI faces 81% higher costs. The variation in import costs are nil. This is also entirely consistent with [Waugh \(2010\)](#)'s results for international trade cost asymmetries.

In the absence of sub-national spatial prices, we cannot separately distinguish between import- and export-costs; so, based on the results for Canada, we assume region-specific import-costs do not vary across regions. That is, we assume $\tau_{ij} \propto D_{ij}^\delta \tau_j^e$. To measure export costs, we use another fixed-effects regression based on Eaton and Kortum (2002). This approach has been used in numerous papers, from [Eaton and Kortum \(2001\)](#) to [Waugh \(2010\)](#) and [Tombe \(2013\)](#). We leave the details to those papers, but it can easily be shown that

$$\ln\left(\frac{\pi_{ij}}{\pi_{ii}}\right) = S_j - S_i - \theta \ln(\tau_{ij}),$$

where the S terms capture region-specific factors such as productivity and factor prices. By assuming $\tau_{ij} \propto D_{ij}^\delta \tau_j^e$ we have

$$\ln\left(\frac{\pi_{ij}}{\pi_{ii}}\right) = \delta \ln(D_{ij}) + \iota_i + \eta_j + \epsilon_{ij}.$$

To distinguish exporter-specific trade costs from the other exporter-specific factors S_j , we perform a particular manipulation of the fixed effects. Notice that $\eta_j = S_j - \theta \ln(\tau_j^e)$ and $\iota_i = -S_i$. So, we infer the exporter specific trade costs as $\hat{\tau}_j^e = e^{-(\hat{\eta}_j + \hat{\iota}_j)/\theta}$. We display our estimates of this regression and the resulting export costs in the last columns of Table 2.

Importantly, both methods yield similar measures of exporter-specific trade costs *even though the approach of regression (2) does not require price data*. Given this, we measure export costs for

Table 1: Bilateral Trade Cost Measures for Canada, in Percent

(a) Using Trade and Production Data

| Importer | Exporter | | | | | | | | | |
|----------|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | AB | BC | MB | NB | NL | NS | ON | PE | QC | SK |
| AB | | 90 | 114 | 204 | 233 | 208 | 93 | 294 | 132 | 94 |
| BC | 90 | | 155 | 242 | 282 | 212 | 114 | 321 | 142 | 153 |
| MB | 114 | 155 | | 232 | 284 | 229 | 115 | 320 | 152 | 112 |
| NB | 204 | 242 | 232 | | 100 | 99 | 139 | 115 | 113 | 244 |
| NL | 233 | 282 | 284 | 100 | | 120 | 157 | 191 | 138 | 323 |
| NS | 208 | 212 | 229 | 99 | 120 | | 129 | 139 | 146 | 254 |
| ON | 93 | 114 | 115 | 139 | 157 | 129 | | 183 | 77 | 120 |
| PE | 294 | 321 | 320 | 115 | 191 | 139 | 183 | | 202 | 351 |
| QC | 132 | 142 | 152 | 113 | 138 | 146 | 77 | 202 | | 177 |
| SK | 94 | 153 | 112 | 244 | 323 | 254 | 120 | 351 | 177 | |

(b) Using Trade, Production, and Price Data

| Importer | Exporter | | | | | | | | | |
|----------|----------|-----|-----|-----|-----|-----|----|-----|-----|-----|
| | AB | BC | MB | NB | NL | NS | ON | PE | QC | SK |
| AB | | 81 | 158 | 265 | 358 | 256 | 73 | 470 | 125 | 129 |
| BC | 98 | | 204 | 330 | 426 | 269 | 87 | 579 | 136 | 209 |
| MB | 77 | 115 | | 235 | 359 | 229 | 64 | 427 | 110 | 107 |
| NB | 154 | 173 | 229 | | 93 | 97 | 70 | 184 | 81 | 237 |
| NL | 141 | 178 | 221 | 109 | | 113 | 66 | 223 | 96 | 291 |
| NS | 165 | 163 | 229 | 101 | 128 | | 68 | 198 | 95 | 240 |
| ON | 115 | 144 | 184 | 237 | 298 | 212 | | 375 | 93 | 184 |
| PE | 172 | 162 | 234 | 63 | 162 | 91 | 68 | | 95 | 244 |
| QC | 139 | 148 | 202 | 150 | 189 | 212 | 62 | 367 | | 243 |
| SK | 65 | 107 | 117 | 253 | 357 | 268 | 70 | 490 | 123 | |

Our measures of the tariff-equivalent internal trade costs between all Canadian provinces. Panel (a) follows Novy (2013) and uses only data on production and trade to estimate trade costs. This method results in a symmetric measure of trade costs between a given pair. Panel (b) follows Waugh (2010) and uses additional price data to distinguish between the direction of trade for a given pair. Overall, poorer regions, such as the Maritime provinces, display higher costs of exporting than richer regions of Canada.

Table 2: Export Specific Internal Trade Costs

| (a) Bilateral Regressions | | | | |
|-----------------------------|----------------------|--------------------------|--|--|
| | Dep. Var. | | | |
| | (1) | (2) | | |
| | $\ln(\tau_{ij})$ | $\ln(\pi_{ij}/\pi_{ii})$ | | |
| $\ln(\text{Distance}_{ij})$ | 0.251*** [0.0149] | -1.255*** [0.0747] | | |
| Exporter FEs | Yes | Yes | | |
| Importer FEs | Yes | Yes | | |
| R^2 | 0.93 | 0.94 | | |
| Obs. | 90 | 90 | | |

| (b) Exporter and Importer Specific Trade Costs, in Percent Relative to Average | | | | |
|--|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Province | Based on Regression (1) | | Based on Regression (2) | |
| | Exporter Costs, $\hat{\tau}_j^e$ | Importer Costs, $\hat{\tau}_i^m$ | Exporter Costs, $\hat{\tau}_j^e$ | Importer Costs, $\hat{\tau}_i^m$ |
| AB | -23.1 | 0.3 | -25.7 | 0.0 |
| BC | -21.6 | -0.5 | -18.6 | 0.0 |
| MB | 6.5 | 0.2 | 4.0 | 0.0 |
| NB | 12.8 | 0.3 | 12.9 | 0.0 |
| NL | 21.2 | 1.0 | 10.1 | 0.0 |
| NS | 13.3 | 0.0 | 13.1 | 0.0 |
| ON | -36.4 | -0.4 | -33.3 | 0.0 |
| PE | 80.8 | -0.1 | 81.9 | 0.0 |
| QC | -19.7 | -0.7 | -14.7 | 0.0 |
| SK | 9.1 | -0.1 | 9.3 | 0.0 |

All exporter effects are precisely estimated in regression (1) while the single precisely estimated importer effect is for Newfoundland, though it is economically insignificant. For the last two columns, based on regression (2) importer specific costs are zero by construction.

each region of Canada, China, and the United States using the approach of regression (2) and display the estimates against regional GDP/capita in panel (d) of Figure 1. Exporter-specific trade costs decrease with income – poor regions within a country have a difficult time exporting, just as [Waugh \(2010\)](#) found internationally for poor countries. These trade cost asymmetries will not be influenced by geographic factors common to two regions and, as with the Head-Reis-Novy measure, are not influenced by a country’s overall trade balance. We quantify the effect of these asymmetries in Section 5 and consider them as more policy-relevant than the Head-Reis-Novy trade cost estimates.

3 A Model of Internal Trade, Migration, and Taxes

To investigate the consequences of internal trade costs, we build upon the recent model of [Redding \(2012\)](#). The model’s core is an [Eaton and Kortum \(2002\)](#) trade model, expanded to allow regions within a country to differ in productive efficiency and to trade with each other and the world. Labour can migrate from one region to another, if such a move would increase utility. Land is fixed and serves as a congestant that allows for a non-degenerate regional distribution of labour in equilibrium. We expand this model to incorporate a non-tradable services sector along the lines of [Alvarez and Lucas \(2007\)](#). We also introduce a government sector that taxes income and provides per-capita transfers. The presence of this tax-and-transfer scheme creates a new source of gains (or losses) from trade liberalization that is analytically derived and quantitatively important. Taxes and transfers also endogenously generate trade imbalances, a unique feature of our model.

Overall, N regions are populated by L_i identical consumers. Region $i = 1, \dots, N - 1$ are within one country and region $i = N$ is the rest of the world. Each region can produce two types of goods: (1) a continuum of *tradable* goods used in the production of (2) a *nontradable* intermediate good. The intermediate is either used in the production of individual varieties or consumed directly. Each consumer inelastically supplies one unit of labour to either the final goods sector or intermediates production. Finally, in the $N - 1$ sub-national regions, a government taxes income and reallocates the revenue lump-sum-equally to all residents. Now, the details.

3.1 Production and Trade

Firms produce differentiated goods, indexed z , using labour, land, and an intermediate input using a Cobb-Douglas technology

$$q_i(z) = \varphi_i(z) l_i(z)^\beta H_{mi}(z)^\eta q_{mi}(z)^{1-\beta-\eta},$$

where $\varphi_i(z)$ is the productivity for variety z in region i and $l_i(z)$, $H_{mi}(z)$, and $q_{mi}(z)$ are the labour, land, and intermediate inputs used for producing variety z . The parameters β and η are the output elasticities with respect to labour and land; they are also each input’s shares of output. The market is perfectly competitive, so prices will equal marginal cost, $\varphi_i(z)^{-1} w_i^\beta r_i^\eta P_i^{1-\beta-\eta}$, where w_i , r_i , and

P_i denote the region i prices for labour, land, and the intermediate.

The intermediate good is a CES composite with elasticity ρ ,

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

where $q_i(z)$ denotes variety z used in region i for the production of q_i . We distinguish between intermediates used in production q_{mi} and the total supply of intermediates q_i since households also consume this good. Similarly for land.

In forming this composite good, individual varieties may be sourced locally within region i or imported from another region, depending on which option minimizes costs. Trade, however, is costly: $d_{ij} \geq 1$ goods are shipped per unit imported by region i from region j , and $d_{ii} = 1$. These trade costs need not be symmetric and therefore d_{ij} may differ from d_{ji} . Given transport costs, the price of variety z in region i is the lowest price charged by any possible producer; that is,

$$p_i(z) = \min_{j \in \{1, \dots, N\}} \frac{d_{ij} w_j^\beta r_j^\eta P_j^{1-\beta-\eta}}{\varphi_j(z)}. \quad (3)$$

As the intermediate good is a CES composite of all varieties, its price is $P_i = \left[\int_0^1 p_i(z)^{1-\rho} dz \right]^{1/(1-\rho)}$. To derive an clean expression for this, a particular distribution of firm productivity is required. As in [Eaton and Kortum \(2002\)](#), we assume $\varphi_i(z)$ are independent random draws from a region-specific Frechet distribution,

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

where lower θ implies higher variability and higher φ_i implies a higher mean. As is standard in these models, the Frechet distributed productivity implies the intermediate good's price in each region i are

$$P_i = \gamma \left[\sum_{j=1}^N \left(\frac{d_{ij} w_j^\beta r_j^\eta P_j^{1-\beta-\eta}}{\varphi_j} \right)^{-\theta} \right]^{-1/\theta}, \quad (4)$$

where $\gamma = \left[\Gamma \left(1 + \frac{1-\rho}{\theta} \right) \right]^{\frac{1}{1-\rho}}$ and $\Gamma(\cdot)$ is the gamma function. For this gamma function to be well defined, we impose $\theta > \rho - 1$.

Finally, the share of region i expenditures allocated to goods from region j (denoted π_{ij}) depends on the fraction of varieties produced in region j that have the lowest price of all producers in any other region, from the perspective of region i . As is also standard in these types of models,

this share is given by

$$\pi_{ij} = \frac{\left(\frac{d_{ij} w_j^\beta r_j^\eta P_j^{1-\beta-\eta}}{\varphi_j} \right)^{-\theta}}{\sum_{k=1}^N \left(\frac{d_{ik} w_k^\beta r_k^\eta P_k^{1-\beta-\eta}}{\varphi_k} \right)^{-\theta}}. \quad (5)$$

Given tradeables expenditures X_i , total revenue in region i is

$$R_i = \sum_{j=1}^N \pi_{ji} X_j. \quad (6)$$

As region i is also within the summation, revenue is earned through sales to buyers in all regions of the world, including locally.

Proposition 1 *Region i 's trade deficit is $D_i = X_i - R_i$.*

Proof: A region's exports are $\sum_{j \neq i} \pi_{ji} X_j = R_i - \pi_{ii} X_i$, its imports are $\sum_{j \neq i} \pi_{ij} X_i$, and therefore $D_i = \sum_{j \neq i} \pi_{ij} X_i + \pi_{ii} X_i - R_i = X_i - R_i$ since $\sum_{j=1}^N \pi_{ij} = 1$. ■

In a typical [Eaton and Kortum \(2002\)](#) model, expenditures will equal firm revenue and the deficit will be zero. In our model, a deficit can exist in a region if government transfers exceed taxes paid. This will be clear shortly, after we describe the consumer problem.

3.2 Consumers, Government, and Wages

The L_i identical consumers in region i each derive utility from a nontradable service good, s_i , a nontradable intermediate good, q_{fi} , and housing services provided by land, H_{fi} . In contrast to intermediates and land use in production (denoted with m), we use f to denote use by final consumers. The representative consumer for this region is endowed with the following utility function,

$$U_i = s_i^\phi \left(q_{fi}^\alpha H_{fi}^{1-\alpha} \right)^{1-\phi}. \quad (7)$$

The parameters α and ϕ govern the relative importance of each type of good or service. Following [Alvarez and Lucas \(2007\)](#), the service good is provided by labour alone; so, s_i is the fraction of labour L_i working in the service sector.

The consumer's objective is to maximize utility subject to a budget constraint. Given total expenditures v_i , the household will allocate ϕv_i to services, $\alpha(1-\phi)v_i$ to goods, and $(1-\alpha)(1-\phi)v_i$ to housing. Households own their region's land and a government levies a tax on all market income, at rate t , and transfers lump-sum payments (tax-free), worth m . As total expenditures equals income,

$$v_i L_i = (w_i L_i + (1-\phi)(1-\alpha)v_i L_i + \eta R_i)(1-t) + m L_i, \quad (8)$$

where ηR_i is the total land payments by firms in region i .

Given a balanced government budget, we can solve for m as a function of the tax rate t and wages. Prior to doing so, we must first determine the share of total employment in services s . Using only optimal firm input demands and consumer expenditure allocations, we show in the following theorem that this share is constant and common across all regions.

Proposition 2 *The share of labour employed in the nontradable service sector s_i is constant, common across regions, and given by*

$$s = \phi \frac{\beta + \eta}{\phi(\beta + \eta) + (1 - \phi)\alpha\beta}.$$

Proof: See appendix.

Without land ($\eta = 0$ and $\alpha = 1$), $s_i = \phi$ as in the tariff-free case of [Alvarez and Lucas \(2007\)](#). With the share from Theorem 2 in hand, we can solve for the government's balanced-budget level of subsidy, given a tax rate t .

Proposition 3 *Given a tax rate t , the per-capita transfer that satisfies balances the government's budget is*

$$m = t \sum_{i=1}^{N-1} v_i \lambda_i, \quad (9)$$

where $\lambda_i \equiv \frac{L_i}{\sum_{j=1}^{N-1} L_j}$ is the country's share of employment in region i .

Proof: See appendix.

Using the above two theorems, we can derive total income and expenditures by region, as a function of wages and fiscal policy. We show a key result that expenditures can differ from wages due to land rental receipts (as in [Redding, 2012](#)) and due to government taxes t and transfers m .

Proposition 4 *Total income and expenditures of each region i is*

$$v_i = \kappa f_i w_i, \quad (10)$$

with $f_N = 1$ and

$$\begin{aligned} \kappa &= \frac{1 + \frac{\eta}{\beta}(1 - s)}{1 - (1 - \phi)(1 - \alpha)}, \\ f_i &= 1 + \left(\frac{t}{1 - (1 - \phi)(1 - \alpha)(1 - t)} \right) \left(\frac{\sum_{i=1}^{N-1} w_i \lambda_i - w_i}{w_i} \right), \quad i \in \{1, N - 1\}. \end{aligned}$$

Proof: See appendix.

The terms κ and f_i are informative and describe two channels through which total income can exceed wage earnings. First, income from land is captured in the first, κ , and is fixed and common across all regions. If there are no service or government sectors ($\phi = t = m = 0$), then

$\kappa = \frac{\beta+\eta}{\alpha\beta}$ and $v_i = \frac{\beta+\eta}{\alpha\beta}w_i$ as in Redding (2012). Second, unique to our paper, is a “fiscal adjustment” f_i that can increase or decrease total income depending on a region’s wage-gap $\frac{\sum_{i=1}^{N-1} w_i \lambda_i - w_i}{w_i}$, reflecting the region’s wage deviation from the national average. Notice that we cannot use this approach to analyze tax competition issues between states, as the tax rate is common to all states. Also, state-level balanced budgets would eliminate the fiscal adjustment margin. Regions with below-average wages will experience a positive fiscal adjustment, as it pays less to the central government than it receives, while regions with above-average wages will experience the reverse. Shocks to the model, such as a reduction in trade costs, will influence equilibrium wages differently in different regions, leading f_i to rise or fall. This will be the basis for the gains from trade results to follow.

We are now ready to solve for equilibrium wages w_i , building on equation (6) and the previous theorems.

Proposition 5 *Given employment L_i and trade shares π_{ji} , equilibrium wages solve*

$$w_i L_i = \sum_{j=1}^N \pi_{ji} w_j L_j F_j, \quad (11)$$

where $F_j = \frac{X_j}{R_j} = \left(\frac{\kappa f_j \beta \alpha (1-\phi)}{1-s} + 1 - \beta - \eta \right)$ is tradables spending to revenue ratio.

Proof: See appendix.

A brief discussion here is in order. If there was no government sector ($f_i = 1$ or, equivalently, $t = m = 0$), then $F_i = 1$. The above equation for equilibrium wages would then appear identical to a standard Eaton and Kortum (2002) model. This term reflects the regional redistribution resulting from the government’s tax and transfer system. If a region receives more in transfers than it pays in taxes, its total spending on tradables could exceed its total firm revenues by a factor of F_i . That is, the net transfers can fund a trade deficit and $X_i = F_i R_i$. Given F_i , and the results of Proposition 1, the deficit to tradables spending ratio is given by $D_i / X_i = 1 - F_i^{-1}$. This will prove useful to calibrate the model later.

3.3 Land Prices

To repeat: all payments to land within a region, either as firm inputs or as housing, are rebated lump-sum to residents of the region. A land market clearing condition can be used to express equilibrium land price r_i as a function of wages, employment, and the total supply of land (denoted H_i). Specifically,

$$r_i H_i = (1 - \phi)(1 - \alpha) \kappa f_i w_i L_i + \eta R_i,$$

which, using $R_i = w_i L_i (1 - s) / \beta$, implies

$$\begin{aligned} r_i &= \frac{w_i L_i}{H_i} \left[(1 - \phi)(1 - \alpha) \kappa f_i + \frac{\eta}{\beta} (1 - s) \right], \\ &\equiv \frac{w_i L_i}{H_i} \Omega_{1i}, \end{aligned} \quad (12)$$

where Ω_{1i} is the economy-wide propensity to spend on land out of an additional dollar of wages. In the absence of fiscal adjustment and the service sector, $\Omega_{1i} = \frac{\beta + \eta - \alpha \beta}{\alpha \beta}$ as in [Redding \(2012\)](#).

3.4 Labour Migration

The representative consumer's welfare is equivalent to real (after-tax) income

$$U_i = \frac{v_i}{w_i^\phi \left(P_i^\alpha r_i^{1-\alpha} \right)^{1-\phi}}. \quad (13)$$

Workers migrate from one region to another depending on where they achieve the highest utility. In equilibrium, real incomes will equalize across regions, creating a common level of utility \bar{U} . Using prior expressions for goods and land prices, and the results from [Theorem 4](#), one can derive

$$\bar{U} = \kappa f_i \left(\frac{\varphi_i}{\gamma \pi_{ii}^{1/\theta}} \right)^{\frac{(1-\phi)\alpha}{\beta+\eta}} \left(\frac{H_i}{L_i \Omega_{1i}} \right)^{\frac{(1-\phi)(\beta+\eta-\alpha\beta)}{\beta+\eta}}.$$

For the sub-national regions $i \in \{1, N - 1\}$, we isolate for labour and express it as a share of the national total (recall, denoted λ_i)

$$\lambda_i = \frac{\left(\varphi_i \pi_{ii}^{-1/\theta} \right)^{\frac{\alpha}{(\beta+\eta-\alpha\beta)}} H_i \Omega_{2i}}{\sum_{j=1}^{N-1} \left(\varphi_j \pi_{jj}^{-1/\theta} \right)^{\frac{\alpha}{(\beta+\eta-\alpha\beta)}} H_j \Omega_{2j}}, \quad (14)$$

where

$$\Omega_{2i} = \Omega_{1i}^{-1} (\kappa f_i)^{(\beta+\eta)/(1-\phi)(\beta+\eta-\alpha\beta)},$$

captures negative real income effects of land price increases (Ω_{1i}^{-1} from [equation 12](#)) and positive effects of increased fiscal adjustments f_i . For the rest of the world, $i = N$, and there is no between-country migration, so $\lambda_N = 1$.

4 Quantitatively Simulating the Model

The purpose of the model is to quantify the importance of changes in trade costs d_{ij} . [Dekle, Eaton and Kortum \(2007\)](#) develop a method, followed by [Redding \(2012\)](#), to solve for equilib-

rium *changes* without requiring we solve the initial or the new equilibrium levels. This is valuable as we need not take a stand on the value of land supply H_i (and therefore r_i), technology φ_i , or on the initial level of trade costs d_{ij} . All we need assume is that H_i and φ_i are constant. To the extent that H_i captures land quality or other immobile amenities that make living and producing in a given region attractive, this assumption seems reasonable. Technology φ_i is also assumed to be independent of changes in trade costs. We outline the set of equations that enable us to measure the model's response to shocks below.

4.1 Equilibrium Response to Shocks

Let $\hat{x} = x'/x$ denote the ratio of a new equilibrium value x' to the original value x . That is, $\hat{w}_i = 1.1$ implies wages increased by 10% from their initial level. From equations (4), (5), (9), (11), (12), and (14),

$$\hat{w}_i \hat{L}_i w_i L_i = \sum_{j=1}^N \pi'_{ji} \hat{w}_j \hat{L}_j w_j L_j F'_j, \quad (15)$$

$$m' = \frac{t \left(1 + \frac{\eta}{\beta} (1-s)\right)}{1 - (1-\phi)(1-\alpha)} \sum_{i=1}^{N-1} w'_i \lambda'_i, \quad (16)$$

$$\hat{r}_i = \hat{w}_i \hat{L}_i \hat{\Omega}_{1i}, \quad (17)$$

$$\pi'_{ji} = \frac{\pi_{ji} \left(\hat{d}_{ij} \hat{w}_j^\beta \hat{r}_j^\eta \hat{P}_j^{1-\beta-\eta}\right)^{-\theta}}{\sum_{j=1}^N \pi_{ji} \left(\hat{d}_{ij} \hat{w}_j^\beta \hat{r}_j^\eta \hat{P}_j^{1-\beta-\eta}\right)^{-\theta}}, \quad (18)$$

$$\hat{P}_i = \left[\sum_{j=1}^N \pi_{ij} \left(\hat{d}_{ij} \hat{w}_j^\beta \hat{r}_j^\eta \hat{P}_j^{1-\beta-\eta}\right)^{-\theta} \right]^{-1/\theta}, \quad (19)$$

$$\lambda'_i = \frac{\lambda_i \hat{\pi}_{ii}^{-\frac{\alpha}{\theta(\beta+\eta-\alpha\beta)}} \hat{\Omega}_{2i}}{\sum_{j=1}^{N-1} \lambda_j \hat{\pi}_{jj}^{-\frac{\alpha}{\theta(\beta+\eta-\alpha\beta)}} \hat{\Omega}_{2j}}. \quad (20)$$

Each of the above equations hold for all regions with the exception of equation (20), which only applies for sub-national regions $i \in \{1, N-1\}$ (see section 3.4).

The value for changes in trade costs (\hat{d}_{ij}) will depend on the experiment; for example, lowering trade costs to 90% of their initial values for all trade pairs implies $\hat{d}_{ij} = 0.9$. The variables that respond to this shock include changes in wages \hat{w}_i , land prices \hat{r}_i , and goods prices \hat{P}_i and new values for transfers m' , trade shares π'_{ij} , and employment shares λ'_i . The initial values for employment L_i and initial trade shares π_{ij} come directly from data, which was outlined and explored in

Section 2.⁵ Given these, employment shares λ_i can be easily found and the initial wage level w_i can also be found by solving equation (11). Exogenous parameters of the prior equations are α , β , η , θ , ϕ , and t .

4.2 The Gains from Trade

Using the above expressions, along with equation (13), we can decompose the change in welfare and present the central proposition of our paper.

Proposition 6 *Changes in region i 's welfare depend on changes in its trade share, share of employment, and fiscal adjustment:*

$$\hat{U}_i = \underbrace{\hat{\pi}_{ii}^{-\frac{\alpha(1-\phi)}{\theta(\beta+\eta)}}}_{\text{Market Access}} \cdot \underbrace{\hat{\lambda}_i^{-\frac{(1-\phi)(\beta+\eta-\alpha\beta)}{\beta+\eta}}}_{\text{Worker Migration}} \cdot \underbrace{\hat{\Omega}_{2i}^{\frac{(1-\phi)(\beta+\eta-\alpha\beta)}{\beta+\eta}}}_{\text{Fiscal Adjustment}}. \quad (21)$$

Proof: See appendix.

This result can be compared with other expressions for the gains from trade. In a standard Eaton and Kortum (2002) model, $\hat{U}_i = \hat{\pi}_{ii}^{-\frac{1}{\theta}}$. Indeed, Arkolakis et al. (2012) demonstrate this expression holds for a broad class of trade models, where θ is the cost-elasticity of trade flows. Including land, intermediate inputs, and the nontradable service sector changes the exponent to $\frac{\alpha(1-\phi)}{\theta(\beta+\eta)}$ but the underlying mechanism for a welfare gain remains. Trade reduces the set of varieties produced locally by shutting down the lowest productivity producers.

The second term in the expression can be compared with Redding (2012), where inward migration ($\hat{\lambda}_i > 1$) leads to higher land prices and lower welfare. We have this same channel in our model, though it is dampened by $(1 - \phi)$ relative to Redding (2012) due to the presence of non-tradable services. This second term is also the primary mechanism that equalizes welfare across regions when labour is mobile. That is, as workers move, $\hat{U}_i = \hat{U}$ for all i , although each of the three components in equation 21 may individually differ between regions.

Our principal contribution in this expression is to cleanly provide for an effect of tax-and-transfer arrangements within a country to influence the gains from trade. The value $\hat{\Omega}_{2i}$ differs from unity only to the extent that f_i changes. If a trade shock leads nominal wages to change relative to the national average for a given region, then the fiscal adjustment to income will also change. More concretely, if relative nominal wages rise then taxes paid will increase relative to transfers received, leading the ratio of income to wages and therefore welfare to decline.

⁵Importantly, we do not have trade shares π_{ij} between US states and the rest of the world. We simulate the US results based only on the 50 states. For Canada and China, we do include a "Rest of the World" region, though display results only for the 10 provinces of Canada and 30 respective provinces of China. All results only change slightly for Canada and China when the rest of the world is removed, indicating the effect of ignoring the world for the US simulations is small.

Table 3: Calibrated Parameters

| Parameter | Description / Target | Values | | |
|-----------|----------------------------------|--------|---------------|-------|
| | | Canada | United States | China |
| α | Goods preference weight | 0.64 | 0.64 | 0.81 |
| ϕ | Services preference weight | 0.45 | 0.45 | 0.37 |
| β | Labour's share of output | 0.40 | 0.40 | 0.28 |
| η | Immobile input's share of output | 0.20 | 0.20 | 0.16 |
| θ | Cost-elasticity of trade | 4.00 | 4.00 | 4.00 |
| t | Income tax rate | 0.31 | 0.27 | 0.12 |

To make this even clearer, consider an alternative form for welfare gains, as derived in the proof of proposition 6,

$$\hat{U}_i = \hat{f}_i \left(\frac{\hat{w}_i}{\hat{p}_i^\alpha \hat{r}_i^{1-\alpha}} \right)^{1-\phi}.$$

The term within the parenthesis is identical to Redding (2012) but is now adjusted by $1 - \phi$ due to nontradable services. The first component of the expression \hat{f}_i captures changes in the region's fiscal adjustment. We will show in the quantitative exercises that \hat{f}_i can often be substantially larger in magnitude than gains due to $\left(\hat{w}_i / \hat{p}_i^\alpha \hat{r}_i^{1-\alpha} \right)^{1-\phi}$. If a region's gains are primarily through increased incomes, then \hat{f}_i will offset those gains. On the other hand, if gains are through reductions in $\hat{p}_i^\alpha \hat{r}_i^{1-\alpha}$, with nominal wage gains concentrated in other regions, then \hat{f}_i will amplify the gains from trade.

4.3 Calibrating the Model

To simulate the model, we require values for α , β , η , θ , ϕ , and t . We calibrate those parameters in this section, with a summary provided in Table 3. Many parameters have straightforward counterparts in data and, not surprisingly, Canada and the United States have similar values that are different from China.

The preference weight for services ϕ is equal to the share of consumer spending allocated to services. Combined with the preference weight for goods relative to land α , one can infer the allocation of spending between services, goods, and land. Statistics Canada's Survey of Household Spending and the US Consumer Expenditure Survey data all indicate approximately 20% of expenditures are allocated to Housing/Shelter. For China, the share is significantly lower, with the 2011 Statistical Yearbook of China indicating a housing share of 13%.⁶ We therefore set $(1 - \alpha)(1 - \phi) = 0.20$ for Canada and the United States and 0.13 for China. These same data also indicate the share of spending on nontradable services. For Canada, we sum expenditures on

⁶Sources: For Canada, 2007 CANSIM Table 203-0021; for the US, 2013 CES Table 1300; for China, 2011 Yearbook Tables 10-5 and 10-25.

household operations, transportation, healthcare, recreation, education, and some other small categories and find 44% of spending is allocated to services. For the United States, the BEA Personal Consumption Expenditure data indicates non-housing services spending is 46% of the total. We split the difference and set $\phi = 0.45$. For China, summing Yearbook shares for services categories yields $\phi = 0.33$. Along with housing shares, α is determined.

On the production side, we use Input-Output data from the OECD Structural Analysis database for the mid-2000s. This database reports output, labour compensation, and intermediate input use for various industries in many countries, including our three. We define the tradable industries as NACE industries 01 through 37. These industries purchase tradable inputs equivalent to 40% of output in Canada and the US and 57% in China. We therefore set $1 - \beta - \eta$ to 0.40 and 0.57, respectively. Since local services in our model are produced directly by labour, we match β to the share of labour compensation *plus* nontradables' inputs relative to output. The data indicates this share is 42% in the US, 38% in Canada, and 28% in China. We therefore we set $\beta = 0.40$ for Canada and the US and to 0.28 for China. The share for immobile (land) inputs is then the remainder.

The parameter that governs the variance of the productivity distribution also determines the trade-cost elasticity of trade flows. There is a huge literature focused on estimating a value for this parameter, with many recent efforts directed at calibrating new-trade models. [Anderson and van Wincoop \(2004\)](#) review the literature and argue a value for θ between 5 and 10 is reasonable. For example, [Alvarez and Lucas \(2007\)](#) set $\theta = 6.67$, [Eaton and Kortum \(2002\)](#) set $\theta = 8.3$, and [Vaugh \(2010\)](#) finds $\theta = 7.9$ for OECD countries. Recently, however, [Simonovska and Vaugh \(2011\)](#) find $\theta \approx 4.5$ when the bias in [Eaton and Kortum \(2002\)](#)'s procedure, also used in [Vaugh \(2010\)](#), is corrected. This is also confirmed by [Parro \(2013\)](#), who uses a novel approach to infer the elasticity from tariff data, and finds $\theta = 4.5$ for capital goods and $\theta = 5.2$ for other tradables. In what follows, we use $\theta = 5$. Importantly, no other parameter, including t , depends on the value of θ .

4.3.1 Calibrating Income Tax Rates

The importance of this parameter for our analysis demands we highlight its calibration at length. First, consider Canada. Income taxes and transfers endogenously generate trade imbalances. They also help the model match nominal income differences across regions. [Figure 2](#) provides a comparison between the model implied trade deficit and nominal income with and without income taxes and lump-sum transfers. Not only must trade deficits be zero in the absence of taxes and transfers but also regional income differences are substantially larger than in the data. If we set the income tax rate to one-third, then trade deficits and income differences well approximate the data. Indeed, the tax that best fits the income differences in data is 0.31. We therefore set $t = 0.31$.

The process to calibrate the tax rates for the United States and China is similar. Trade deficits are clearly evident in the Chinese and US data. Indeed, as for Canada, the magnitude of the deficit relative to total expenditures is decreasing with the average per capita income of each state or province. We search over tax rates to best match the deficit and income data and set $t = 0.27$ for the US and $t = 0.12$ for China. We provide a comparison of the model implied trade imbalanced

to data in last four panels of Figure 2. The model performs well except for a few US states that deviate from the model's income prediction. Given the good fit overall, we proceed with our analysis.

The similarity of these rates to overall tax revenue shares of GDP is striking. The Heritage Foundation's 2012 Index of Economic Freedom reports tax revenue as a share of GDP of approximately 17% in China, 27% in the United States, and 32% in Canada. This is notable as a naive approach would simply be to set the tax rate equal to the government's revenue share of national income. As it turns out, this wouldn't have been a bad strategy and lends support to the values we use.

5 Quantitative Exercises

With the model now calibrated, we proceed to our quantitative experiments. We begin with a simple experiment to clarify how changes in a region's fiscal adjustment influence gains from trade. Following this, we simulate more revealing experiments: lowering the estimated internal trade costs from Section 2 by 10% and 100%; eliminating asymmetries in trade costs between partners; and, for China and Canada, lowering international (external) trade costs.

Reducing Measured Internal Trade Barriers

In Section 2, we used a flexible measure of trade costs based on [Novy \(2013\)](#) to estimate internal barriers in Canada, China, and the United States. While most of these costs are likely beyond the control of policy-makers, we can simulate a modest reduction in these costs to understand their consequences. Here, we simulate the effect of a 10% reduction by setting $\hat{d}_{ij} = \frac{1+0.9\tau_{ij}}{1+\tau_{ij}}$, where τ_{ij} are our initial trade cost estimates, and $\hat{d}_{ii} = 1$. With this, solve the system described in Section 4.1. Table 4 provides measures of the employment and welfare effects for regions of each country, grouped according to a region's relative nominal income levels. That is, results in the "Bottom 25%" column display the average change in employment or welfare for regions that have income in the bottom quartile.

The results of our main model are displayed in panel (a) and illustrated in Figure 3. While migration flows ensure welfare changes are equalized across regions, the poor regions see larger welfare increases due to improved market access. The bottom quartile has welfare increases from market access of 0.6%, 1.0%, and 1.8% in Canada, the US, and China, respectively, compared to only 0.4%, 0.8%, and 1.2% for the top quartile. This suggests increased trade allows poorer regions to discontinue production from more local producers, leading to higher productivity gains, than richer regions. On their own, these direct gains from trade would increase welfare disproportionately in poor regions but for the inward migration it generates. Increases in population/labour in these regions lowers wages and increases land prices, subtracting from gains from trade. The story does not end there, as taxes on nominal incomes and per-capita transfers also come into play. Inward migration lowers wages (a negative effect on welfare) *and* tax payments (a positive effect).

Table 4: Effect of 10% Lower Internal Trade Costs, by Regional Income

| Change in | Canada | | | United States | | | China | | |
|---|--------|--------|---------|---------------|--------|--------|--------|--------|--------|
| | Bottom | Middle | Top | Bottom | Middle | Top | Bottom | Middle | Top |
| | 25% | 50% | 25% | 25% | 50% | 25% | 25% | 50% | 25% |
| <i>(a) Baseline Model</i> | | | | | | | | | |
| Population/Labour | 1.71% | 0.57% | 0.17% | 1.45% | 0.29% | -0.42% | 2.48% | 0.40% | -0.13% |
| Welfare | 0.33% | 0.33% | 0.33% | 0.81% | 0.81% | 0.81% | 1.17% | 1.17% | 1.17% |
| Market Access | 0.61% | 0.45% | 0.40% | 1.00% | 0.80% | 0.84% | 1.78% | 1.28% | 1.16% |
| Migration | -0.53% | -0.18% | -0.05%* | -0.45% | -0.09% | 0.13% | -0.75% | -0.12% | 0.04% |
| Fiscal Adj. | 0.26% | 0.06% | -0.01% | 0.27% | 0.10% | -0.16% | 0.15% | 0.01% | -0.03% |
| <i>(b) Model Without Migration</i> | | | | | | | | | |
| Population/Labour | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Welfare | 0.64% | 0.45% | 0.37% | 1.12% | 0.89% | 0.72% | 1.80% | 1.29% | 1.15% |
| Market Access | 0.62% | 0.46% | 0.40% | 1.01% | 0.81% | 0.84% | 1.83% | 1.30% | 1.16% |
| Migration | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Fiscal Adj. | 0.02% | -0.01% | -0.03% | 0.11% | 0.09% | -0.11% | -0.03% | 0.00% | -0.01% |
| <i>(c) Model Without Taxes or Transfers</i> | | | | | | | | | |
| Population/Labour | 1.07% | 0.42% | 0.16% | 0.32% | 0.43% | -0.05% | 1.48% | 0.72% | -0.30% |
| Welfare | 0.34% | 0.34% | 0.34% | 0.82% | 0.82% | 0.82% | 1.19% | 1.19% | 1.19% |
| Market Access | 0.67% | 0.47% | 0.39% | 0.92% | 0.95% | 0.80% | 1.65% | 1.41% | 1.10% |
| Migration | -0.34% | -0.13% | -0.05% | -0.10% | -0.13% | 0.02% | -0.45% | -0.21% | 0.10% |
| Fiscal Adj. | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| <i>(d) Model Without Migration, Taxes, or Transfers</i> | | | | | | | | | |
| Population/Labour | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Welfare | 0.69% | 0.47% | 0.39% | 0.92% | 0.96% | 0.80% | 1.68% | 1.44% | 1.09% |
| Market Access | 0.69% | 0.47% | 0.39% | 0.92% | 0.96% | 0.80% | 1.68% | 1.44% | 1.09% |
| Migration | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Fiscal Adj. | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Displays the change in employment and welfare from lowering measured internal trade barriers by 10%. The three components of welfare changes are in italics and combine to equal the overall welfare effect. Each column presents the mean change for all regions within a given income group. The second and third panels present the results when migration is not permitted and when there are no taxes or transfers. Finally, the bottom panel displays the results when there is neither migration nor taxes and transfers – this is the basic Eaton-Kortum setup. * Driven by large migrant inflow to Newfoundland and Labrador. Only Ontario and Quebec experience welfare gains from migration. See Figure 3(c).

Overall, the bottom quartile gains 0.2-0.3% from fiscal adjustment – a sizable fraction of overall gains. It is clear in Figure 3 that the welfare gains from trade due to migration are increasing in a region’s initial income while welfare gains from fiscal adjustment are decreasing.

Further discussion on this fiscal adjustment may be helpful. Regions whose nominal income declines relative to the national average will experience an increase in their fiscal adjustment, resulting in higher gains from trade. This effect can be quantitatively important for a number of regions, especially the poor ones. Land prices, however, increase from the additional spending on housing and land inputs that this transfer facilitates, offsetting some of the welfare gains from the transfer. The net effect, captured by $\hat{\Omega}_{2i}$ in equation 21 is a welfare increase from the increased fiscal adjustment for poor regions but a welfare decrease from this channel for rich regions. Our quantitative results suggest national taxes and transfers matter for the gains from internal trade. For many regions of the United States, which are typically poorer than average, one-third or more of the welfare change is due to fiscal adjustment.

We can further explore the effect of internal trade liberalization by removing migration and taxes from the model. When migration flows are prohibited, welfare gains from trade are larger in poor regions but fiscal adjustments plays very little role. We display these results in the second panel of Table 4 and more systematically in panel(a) of Figure 3. Welfare changes are driven almost entirely by improved market access. When migration is permitted but taxes are absent, market access still favours poorer regions but the induced inward migration lowers their wages and increases land price, offsetting the gains from improved market access. This story is the same as before, except for one key detail: the migration flows are smaller. Without taxes and transfers compensating for changes in relative nominal incomes, only a small flow of migrants is needed to equalize overall welfare changes. Consider the bottom quartile in the United States, where population increased by 1.45% when fiscal adjustment occurs but by only 0.32% when it does not. The internal migration response to trade liberalization therefore depends crucially on the presence of taxes and transfers.

Overall, migration and taxes are quantitatively important to evaluate the gains from internal trade liberalization. We next turn to a more policy-relevant set of experiments, where trade cost asymmetries are removed. In this case, gains from trade even qualitatively depend on fiscal adjustments.

Eliminating Asymmetries in Internal Trade Barriers

It is well known that asymmetric trade-costs are important between countries (see [Vaugh, 2010](#)) and this is a more policy-relevant experiment. That is, measured internal trade costs depend on factors beyond the control of policy-makers, such as distance between trading partners. Asymmetries, however, reflect differences in costs depending on the direction of trade flows. If the costs of trade between New York and Tennessee differ depending on the direction of the trade flow, then some region-specific factor (such as a policy in one state or another) is at play rather than some common impediment such as distance, road quality, and so on. We will also outline here an

important difference with [Waugh \(2010\)](#)'s results.

To perform this simulation, consider the exporter-specific costs outlined in Section 2.2. If region i has larger exporter-specific costs than region j ($\tau_i^e > \tau_j^e$) then $\tau_{ij} < \tau_{ji}$. If region i were to adopt region j 's exporter costs, then $\tau'_{ji} = \tau_{ji}\tau_j^e/\tau_i^e$ and, therefore, $\hat{d}_{ij} = \tau_j^e/\tau_i^e$. More generally, for any possible pairs, we set $\hat{d}_{ij} = \min\{1, \tau_i^e/\tau_j^e\}$. That is, for regions that are importing from an exporter with a higher export cost than themselves, we lower trade costs by presuming the exporter received the importing region's export cost; otherwise, trade costs do not change. Overall, export costs decline in poor regions and, consequently, their supply of goods to the rest of the country increases.

Removing internal trade cost asymmetries results in rising relative income in poor regions, a reduction in their share of the national population, and a reduction in their fiscal adjustments. We present these patterns for each country and all regions in Figure 4. When poor regions experience an increase in export demand, their wages grow and their fiscal adjustments decline. As goods become cheaper in other parts of the country, workers move towards those regions out of the poorer areas. This further increases welfare in poor regions, as outward migration increases wages and decreases land prices. Higher wages, though, will result in fiscal adjustments declining. As is clear in panel (d) of the figure, many poorer regions of the US, for example, see welfare declines on the order of 10% due to shrinking fiscal adjustments, compared to corresponding welfare increases of 5% from improved market access.

While [Waugh, 2010](#) finds removing international asymmetries between benefits poor countries, we find the opposite within a country due to taxes-and-transfers. This is an important result. Consider the top panel of Figure 4, which provides a measure of the overall welfare change when migration is not permitted (analogous to the international context). Gains from market access are always positive and larger in poor regions compared to rich regions. But, overall gains are smaller in poor regions. Many regions actually experience *welfare losses*. These results are entirely driven by reductions in their fiscal adjustments., which can be on the order of -10% or larger for poor US states.

Lowering International Trade Costs

We end our quantitative exercises with a brief exploration of lowering international trade costs. We set the cost of trading across a national boundary at 80% of its initial level for all regions, which implies $\hat{d}_{iN} = 0.8$ and $\hat{d}_{Nj} = 0.8$ for all for all $i, j < N$ and $\hat{d}_{ij} = 1$ otherwise. We can only simulate Canada and China, as the US Consumer Flow Survey 2007 data does not provide information on international flows. We plot the results of this simulation in Figure 5.

Lower international barriers disproportionately benefits regions of above-average incomes. While migration ensures that welfare gains are equalized across regions, the gains due to improved market access are significantly higher in rich regions. For richer regions of Canada, such as Ontario and Alberta, the gains due to market access exceed 5%. For China, coastal regions also gain, with most welfare gains from market access above 2% and many above 5%. In response,

workers move towards those regions, which increases nominal incomes and lowers land prices in poor regions. This leads the welfare gains from migration to decline with regional incomes. This channel is also responsible for a significant welfare reduction in rich regions of China, with some welfare declines in excess of 3%. Fiscal adjustments will disproportionately benefit poor regions: as nominal incomes decline there, so do tax payments. For China, interior region welfare increases due to fiscal adjustment and is roughly the same magnitude as gains from market access. Thus, market access, migration, and fiscal adjustments matter for quantifying gains from trade.

6 Conclusion

The internal gains from trade are distinct from national aggregate gains. First, labour is mobile and responds to changes in regional incomes and living costs. The implications of this were studied recently by [Redding \(2012\)](#), upon whose work we build. Second, government income taxes are levied on nominal, not real, incomes. As gains from trade can come through changes in income, which has tax implications, or in the cost-of-living, which does not, tax policy matters for the spatial distribution of the gains from trade. We develop a model that builds on Redding's model of trade and migration to also include a central government that taxes nominal income and spends on a per-capita basis consistent with [Albouy \(2009\)](#). We explicitly decompose the gains from trade into improved market access (the classic source of gains), migration, and fiscal adjustments.

Beyond deriving the components of internal gains from trade, we demonstrate that the scope for internal trade liberalization is large. We measure internal trade costs using a flexible approach that holds across a wide range of trade models. For Canada, the United States, and China, these tariff-equivalent costs average between 100% and 140%. They are particularly high for poor regions and when it is the poor region exporting. Using our model, we simulate the effect of lowering these costs and find they are substantial. Lowering these measured barriers by 10% will increase welfare by between 0.4% for Canada, 0.8% for the United States, and 1.2% for China. Among the bottom quartile of regions in Canada, the United States, and China, tax effects respectively account for nearly all, one-third, and one-sixth of overall welfare gains. The presence of taxes and transfers can also matter qualitatively. In contrast to the results in [Vaugh \(2010\)](#), removing trade cost asymmetries disproportionately benefits rich regions — this is entirely driven by tax effects. Tax policies are therefore quantitatively important, especially for poor regions, and should be incorporated into research on the gains from internal trade and the spatial distribution within-countries of overall gains from trade.

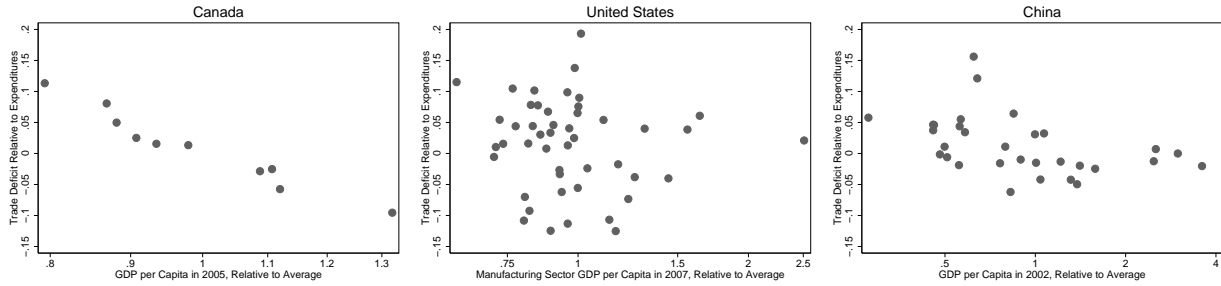
References

- Agnosteva, Delina, James Anderson, and Yoto Yotov**, "Intra-national Trade Costs: Measurement and Aggregation," *NBER Working Paper 19872*, 2014.
- Aguayo-Tellez, Ernesto and Marc-Andreas Muendler**, "Globalization and Formal-Sector Migration in Brazil," 2009.
- Albouy, David**, "The Unequal Geographic Burden of Federal Taxation," *Journal of Political Economy*, 2009, 117 (4), 635–667.
- Allen, Treb and Costas Arkolakis**, "Trade and the Topography of the Spatial Economy," 2013.
- Alvarez, Fernando and Robert Lucas**, "General equilibrium analysis of the Eaton-Kortum model of international trade," *Journal of Monetary Economics*, 2007, 54 (6), 1726–1768.
- Anderson, James E. and Eric van Wincoop**, "Trade Costs," *Journal of Economic Literature*, 2004, 42 (3), 691–751.
- Arkolakis, Costas, Arnaud Costinot, and Andres Rodriguez-Clare**, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, 102 (1), 94–130.
- Atkin, David and Dave Donaldson**, "Who's Getting Globalized? The Size and Nature of Intra-national Trade Costs," 2013.
- Beaulieu, Eugene, James Gaisford, and Jim Higginson**, *Interprovincial trade barriers in Canada: How far have we come? Where should we go?*, Van Horne Institute for International Transportation and Regulatory Affairs, 2003.
- Caliendo, Lorenzo, Fernando Parro, Esteban Rossi-Hansberg, and Pierre-Daniel Sarte**, "The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy," 2013.
- Chen, Natalie**, "Intra-national versus international trade in the European Union: why do national borders matter?," *Journal of International Economics*, 2004, 63 (1), 93–118.
- Cosar, Kerem and Pablo Fajgelbaum**, "Internal Geography, International Trade, and Regional Outcomes," 2012.
- Dekle, Robert, Jonathan Eaton, and Samuel Kortum**, "Unbalanced Trade," *American Economic Review*, 2007, 97 (2), 351–355.
- Eaton, Jonathan and Samuel Kortum**, "Trade in capital goods," *European Economic Review*, 2001, 45 (7), 1195–1235.
- and —, "Technology, Geography, and Trade," *Econometrica*, 2002, 70 (5), 1741–1779.
- Head, Keith and John Ries**, "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade," *American Economic Review*, 2001, 91 (4), 858–876.
- and **Thierry Mayer**, "Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade," Working Papers 2002-01, CEPII research center 2002.

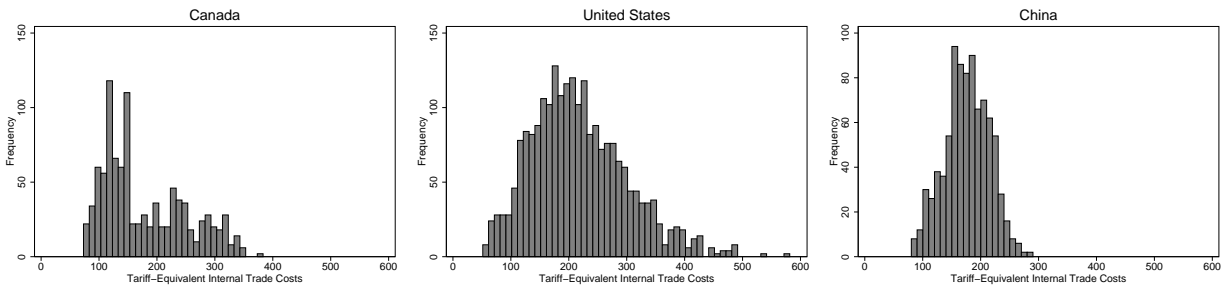
- Helliwell, John F. and Genevieve Verdier**, "Measuring internal trade distances: a new method applied to estimate provincial border effects in Canada," *Canadian Journal of Economics*, 2001, 34 (4), 1024–1041.
- Hering, Laura and Rodrigo Pailacar**, "How does market access shape internal migration?," 2012.
- Hillberry, Russell and David Hummels**, "Intranational Home Bias: Some Explanations," *The Review of Economics and Statistics*, 2003, 85 (4), 1089–1092.
- **and –**, "Trade responses to geographic frictions: A decomposition using micro-data," *European Economic Review*, 2008, 52 (3), 527 – 550.
- Hummels, David**, "Toward a Geography of Trade Costs," 2001. Available at <http://krannert.purdue.edu/faculty/hummelsd/research/toward/TGTC.pdf>.
- McCaig, Brian and Nina Pavcnik**, "Export markets and labor allocation in a poor country," 2012.
- Nitsch, Volker**, "National borders and international trade: evidence from the European Union," *Canadian Journal of Economics*, 2000, 33 (4), 1091–1105.
- Novy, Dennis**, "Gravity Redux: Measuring International Trade Costs With Panel Data," *Economic Inquiry*, 2013, 51 (1), 101–121.
- Parro, Fernando**, "Capital-Skill Complementarity and the Skill Premium in a Quantitative Model of Trade," *American Economic Journal: Macroeconomics*, 2013, 5 (2), 72–117.
- Poncet, Sandra**, "A Fragmented China: Measure and Determinants of Chinese Domestic Market Disintegration," *Review of International Economics*, 2005, 13 (3), 409–430.
- Redding, Stephen J.**, "Goods Trade, Factor Mobility and Welfare," *NBER Working Paper 18008*, 2012.
- Simonovska, Ina and Michael E. Waugh**, "The Elasticity of Trade: Estimates and Evidence," Working Paper 16796, National Bureau of Economic Research 2011.
- Tombe, Trevor**, "The Missing Food Problem," 2013.
- Waugh, Michael E.**, "International Trade and Income Differences," *American Economic Review*, 2010, 100 (5).
- Wolf, Holger C.**, "Intranational Home Bias In Trade," *The Review of Economics and Statistics*, 2000, 82 (4), 555–563.
- Wong, Anna**, "Measuring Trade Barriers: An Application to China's Domestic Trade," 2012.

Figure 1: Measures of Internal Trade Deficits and Costs

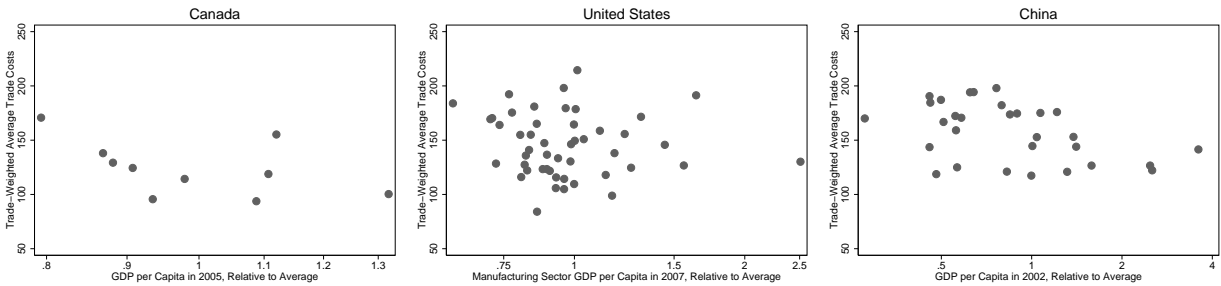
(a) Deficit to Tradables Expenditure Ratio



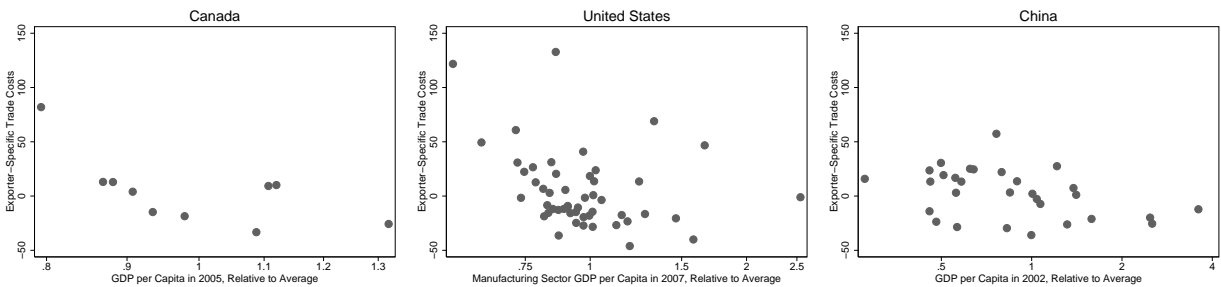
(b) Histograms of Internal Trade Costs for All Regional Pairs



(c) Trade-Weighted Average Internal Trade Costs

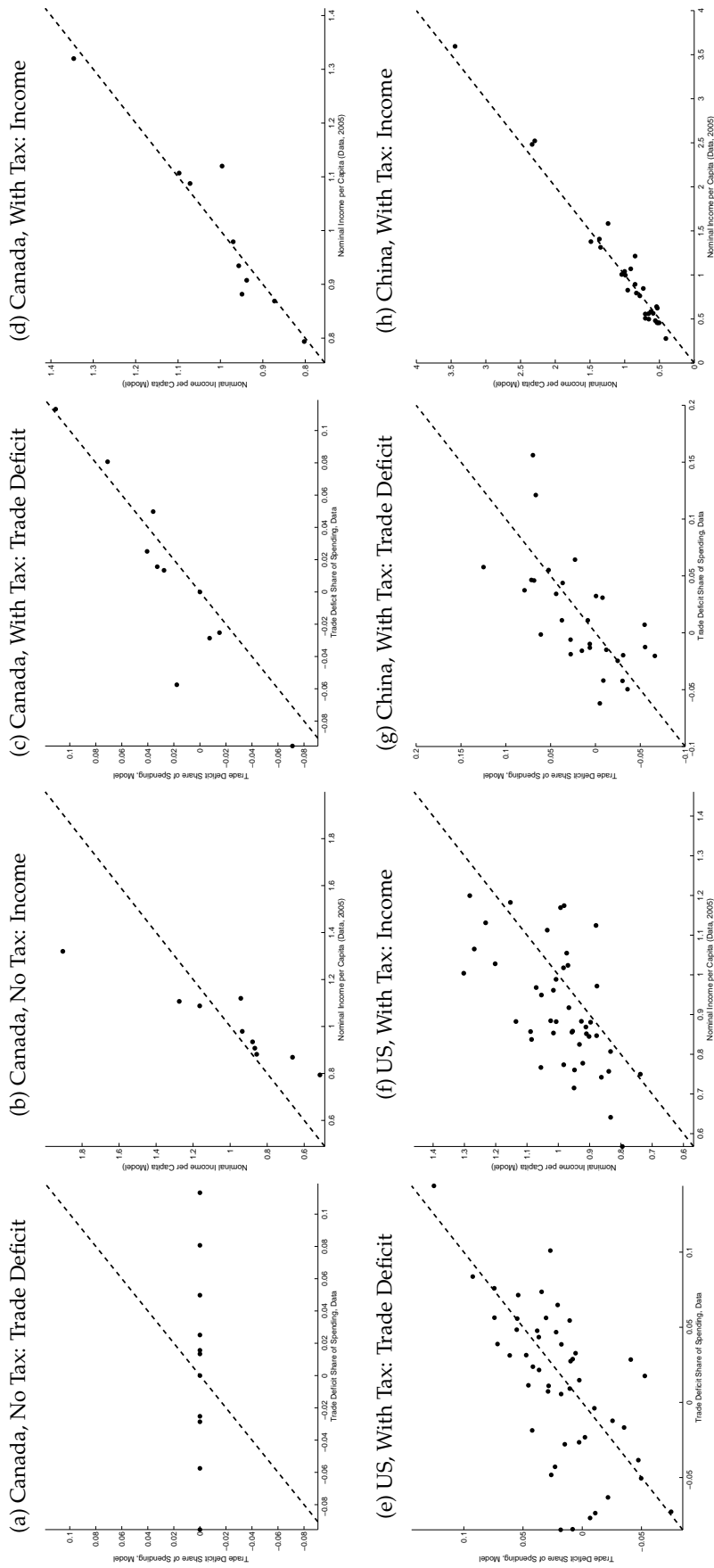


(d) Exporter-Specific Internal Trade Costs



Displays internal trade patterns (deficits) and costs across regions of each country. The first panel is the deficit to tradables expenditure ratio is calculated as $(1 + Y_i/D_i)^{-1}$, where Y_i is output and D_i is imports less exports. Manufacturing GDP/capita is used for the United States as the coverage of the Commodity Flow Survey is narrower than the internal trade data for Canada and China, and focused on industrial flows. The second panel is a histogram of all trade cost measures between all possible regional pairs in each country. In the third panel, costs are averaged across all source, weighted by trade volume, for each importing region. We exclude Alaska and Hawaii from the US plots as they distort the scaling. The final panel displays the exporter-specific trade costs, using the regression approach described in Section 2.2.

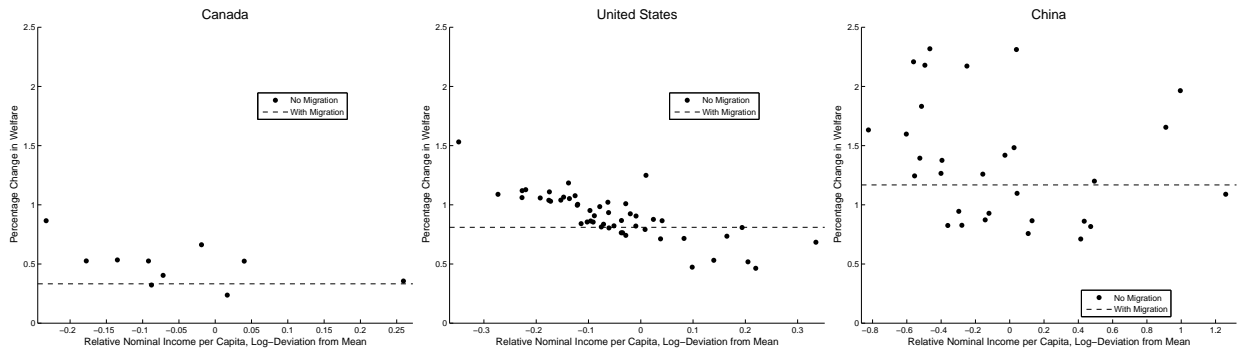
Figure 2: Comparing Model to Data



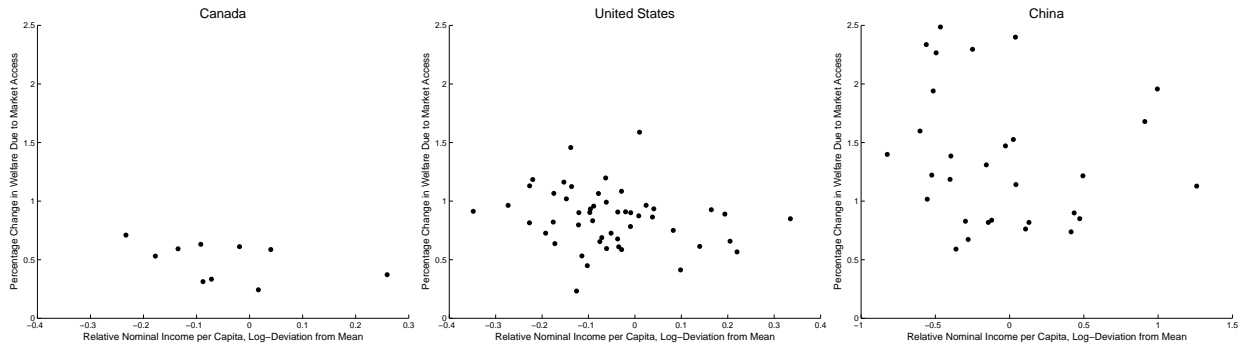
We compare the model to data with the best-fit income tax rates. To illustrate the effect of the tax, panels (a)-(d) show the fit for Canada with and without the best-fit tax. Trade deficits are expressed relative to total spending (D_i/X_i in the model). Nominal income in the model is compared to nominal GDP per capita in data. The income graphs are expressed relative to the national average. For the US, we do not include Tennessee in the deficit plot (as it is an outlier).

Figure 3: Welfare Effects of 10% Lower Internal Trade Barriers

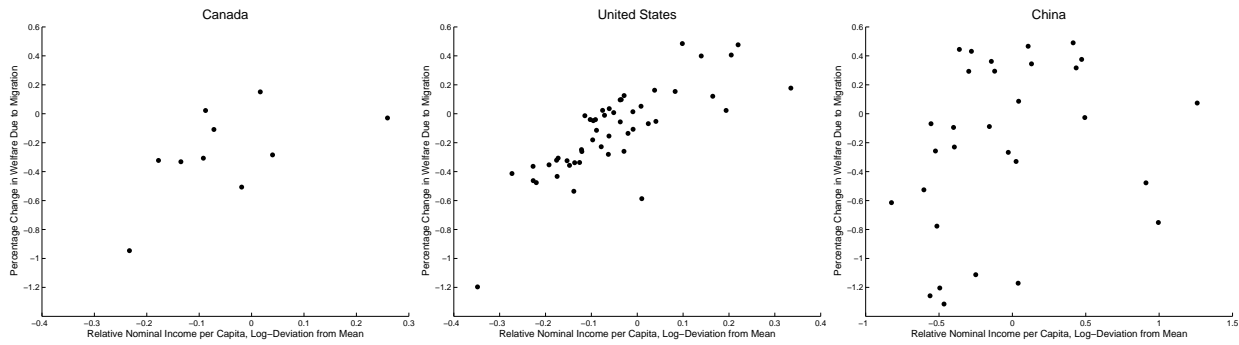
(a) Change in Regional Welfare



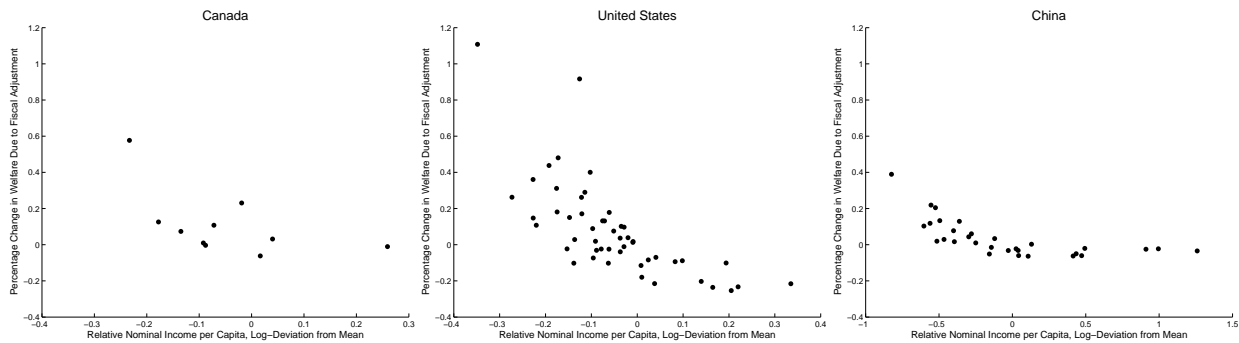
(b) Change in Welfare Due to Market Access



(c) Change in Welfare Due to Migration



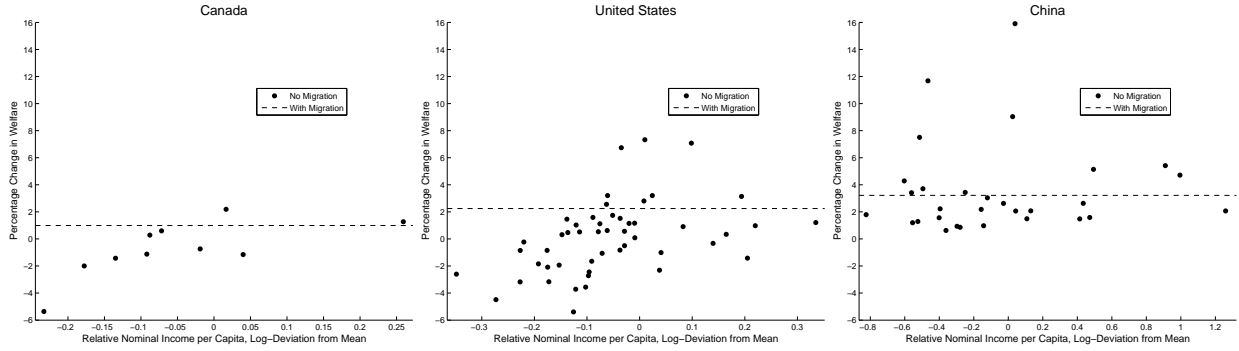
(d) Change in Welfare Due to Fiscal Adjustment



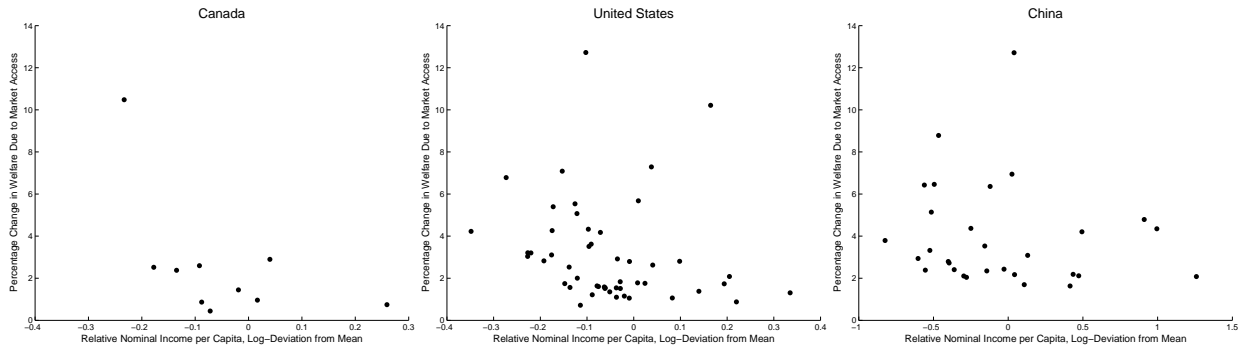
Displays the change in each component of welfare resulting from 10% lower internal trade barriers. The top panel displays the welfare changes when migration is and when it is not permitted. The bottom three panels display the components of welfare changes when migration is permitted. The sum of the three components in panels (b)-(d) will equal the overall change in welfare.

Figure 4: Welfare Effects of Eliminating Asymmetries in Internal Trade Barriers

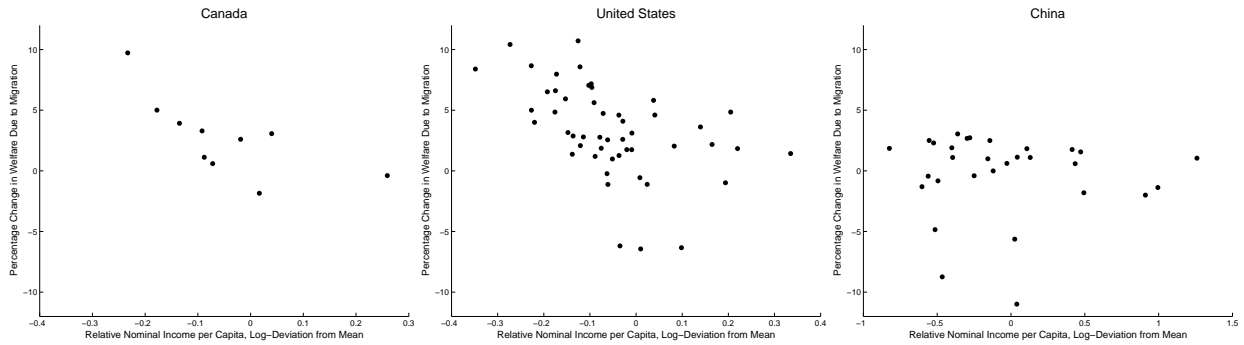
(a) Overall Welfare Change, With and Without Migration



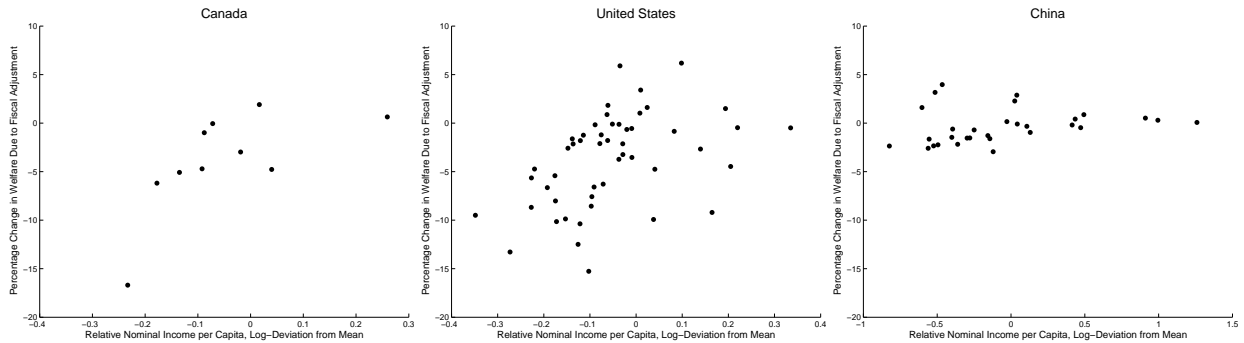
(b) Change in Welfare Due to Market Access



(c) Change in Welfare Due to Migration

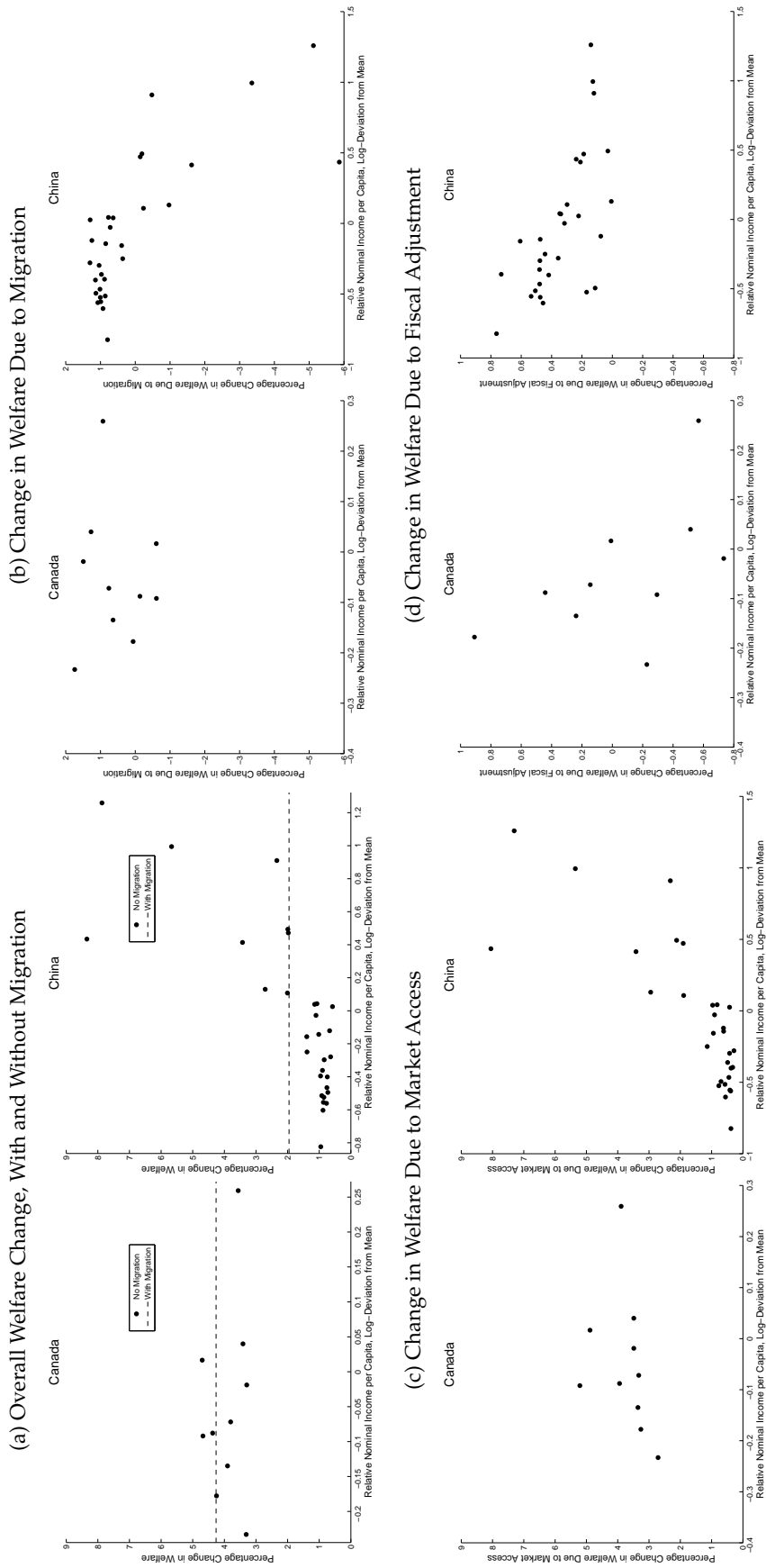


(d) Change in Welfare Due to Fiscal Adjustment



Displays the change in each component of welfare resulting from an elimination of the asymmetries in internal trade barriers. The top panel displays the welfare changes when migration is and when it is not permitted. The bottom three panels display the components of welfare changes when migration is permitted. The sum of the three components in panels (b)-(d) will equal the overall change in welfare.

Figure 5: Welfare Effects of Lowering International Trade Barriers



Displays the change in each component of welfare resulting from lowering international trade costs to 80% of their initial level. The top panel displays the welfare changes when migration is and when it is not permitted. The bottom three panels display the components of welfare changes when migration is permitted. The sum of the three components in panels (b)-(d) will equal the overall change in welfare.

Appendix A: Data and Variable Construction

Distance Between Regions

To measure distance between sub-national regions, we go beyond the standard measure of Great Circle distance between capital cities and measure the population-weighted average distance between populated settlements within each region. Data from the Global Rural-Urban Mapping Project (GRUMP Version 1)⁷ contains population, longitude, and latitude data on many populated settlements within each region. For example, even tiny Prince Edward Island of Canada has seven listed settlements in this data. For each settlement i we determine the distance to all other settlements j using the Great Circle formula. The population-weighted distance between i in region h and all settlements j in another region k is then given by $\sum_{j \in k} \text{dist}_{ij} \omega_j$, where $\omega_j = \frac{p_j}{\sum_{i \in k} p_i}$ is population share of settlement j within its region. We then take the average within each region to arrive at the population-weighted distance between regions h and k , $D_{hk} = \sum_{i \in h} \omega_i (\sum_{j \in k} \text{dist}_{ij} \omega_j)$. Intuitively, this measures the distance between typical residents of two regions and is in line with [Helliwell and Verdier \(2001\)](#) and [Head and Mayer \(2002\)](#).

Appendix B: Proofs of Theorems

Proof of Theorem 2: As services are produced directly by labour, the price of one unit of service is labour's wage w_i . Total spending on services is then $w_i s_i$ and equals a constant fraction ϕ of total expenditures. Similarly, spending on goods $P_i q_{fi}$ is a fraction $\alpha(1 - \phi)$ of expenditures. Given these optimal allocations between services and goods, $w_i s_i = \frac{\phi}{\alpha(1 - \phi)} P_i q_{fi}$. From the firm's input problem, spending on intermediate goods is $P_i q_{mi} = (1 - \beta - \eta) R_i$. Given total revenue $R_i = P_i q_i$ and intermediate goods market clearing $q_i = q_{fi} + q_{mi}$, we have $q_i - q_{fi} = (1 - \beta - \eta) q_i$ or, equivalently, $q_{fi} = q_i(\beta + \eta)$. Using this result in the expression for $w_i s_i$ we have $w_i s_i = \frac{\phi}{\alpha(1 - \phi)} P_i q_i(\beta + \eta)$. As our final step, note the firm's problem also implies $w_i(1 - s_i) = \beta P_i q_i$. To establish the proposition, combine these last two expressions to eliminate $P_i q_i$ and isolate s . ■

Proof of Theorem 3: Government revenue is raised through a tax t placed on market income. Total revenue is therefore $t \sum_{i=1}^{N-1} w_i L_i + (1 - \phi)(1 - \alpha)v_i L_i + \frac{\eta}{\beta}(1 - s)w_i L_i$, which is more compactly expressed as $t \sum_{i=1}^{N-1} \left(\frac{v_i - m}{1 - t}\right) L_i$. Total expenditure is simply $m \sum_{i=1}^{N-1} L_i$. Using the definition for the share of labour in region i , $\lambda_i = L_i / \sum_{j=1}^{N-1} L_j$, and the first expression for v_i from Theorem 4, the

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

balanced budget condition can be expressed as

$$\begin{aligned} m &= t \sum_{i=1}^{N-1} \left(\frac{v_i - m}{1-t} \right) \lambda_i, \\ &= t \sum_{i=1}^{N-1} \left(\frac{v_i}{1-t} \right) \lambda_i - \frac{t}{1-t} m. \end{aligned}$$

Isolating m and rearranging yields

$$m = t \sum_{i=1}^{N-1} v_i \lambda_i,$$

which is our result. Alternative, we could derive

$$\begin{aligned} m &= t \sum_{i=1}^{N-1} w_i \lambda_i + (1-\phi)(1-\alpha)v_i \lambda_i + \frac{\eta}{\beta}(1-s)w_i \lambda_i, \\ &= t \sum_{i=1}^{N-1} w_i \lambda_i \left[1 + (1-\phi)(1-\alpha) \left(\frac{\left(1 + \frac{\eta}{\beta}(1-s)\right)(1-t) + \frac{m}{w_i}}{1 - (1-\phi)(1-\alpha)(1-t)} \right) + \frac{\eta}{\beta}(1-s) \right], \\ &= t \left[\frac{1 + \frac{\eta}{\beta}(1-s)}{1 - (1-\phi)(1-\alpha)(1-t)} \right] \sum_{i=1}^{N-1} w_i \lambda_i + \frac{t(1-\phi)(1-\alpha)m}{1 - (1-\phi)(1-\alpha)(1-t)}, \\ &= \frac{t \left(1 + \frac{\eta}{\beta}(1-s)\right)}{1 - (1-\phi)(1-\alpha)} \sum_{i=1}^{N-1} w_i \lambda_i, \end{aligned}$$

though we find this less intuitive, it is useful in the next theorem. ■

Proof of Theorem 4: Given the optimal firm's input choices, and specifically that spending on land relative to labour inputs is constant at η/β , total expenditures in region i can be simplified through some straightforward manipulations to

$$v_i = \frac{\left(1 + \frac{\eta}{\beta}(1-s)\right)(1-t) + \frac{m}{w_i}}{1 - (1-\phi)(1-\alpha)(1-t)} w_i.$$

It will prove useful to further simply this expression. Using the result of Theorem 3, insert the expression for m into the above expression and rearrange to get

$$v_i = \frac{1 + \frac{\eta}{\beta}(1-s)}{1 - (1-\phi)(1-\alpha)} \left(1 + \frac{t}{1 - (1-\phi)(1-\alpha)(1-t)} \right) \left(\frac{\sum_{i=1}^{N-1} w_i \lambda_i - w_i}{w_i} \right) w_i.$$

The theorem follows by defining the constant as $\kappa = \frac{1 + \frac{\eta}{\beta}(1-s)}{1 - (1-\phi)(1-\alpha)}$ and the fiscal adjustment as $f_i = 1 + \left(\frac{t}{1 - (1-\phi)(1-\alpha)(1-t)} \right) \left(\frac{\sum_{i=1}^{N-1} w_i \lambda_i - w_i}{w_i} \right)$. ■

Proof of Theorem 5: Spending on tradables is

$$X_i = \alpha(1 - \phi)v_i L_i + (1 - \beta - \eta)R_i.$$

This is allocated across sources according to π_{ij} derived earlier. Therefore,

$$R_i = \sum_{j=1}^N \pi_{ji} (\alpha(1 - \phi)v_j L_j + (1 - \beta - \eta)R_j).$$

Using firm labour demand, and the results of Theorems 2 and 4, we have

$$\frac{w_i(1-s)L_i}{\beta} = \sum_{j=1}^N \pi_{ji} \left(\alpha(1 - \phi)\kappa f_j w_j L_j + (1 - \beta - \eta) \frac{w_j(1-s)L_j}{\beta} \right).$$

and, therefore, $w_i L_i = \sum_{j=1}^N \pi_{ji} w_j L_j \left(\frac{\kappa f_j \beta \alpha (1 - \phi)}{1 - s} + 1 - \beta - \eta \right)$. ■

Proof of Theorem 6: Taking the ratio of welfare levels in equation (13),

$$\begin{aligned} \hat{U}_i &= \frac{\hat{v}_i}{\hat{w}_i^\phi (\hat{P}_i^\alpha \hat{r}_i^{1-\alpha})^{1-\phi}} \\ &= \hat{f}_i \left(\frac{\hat{w}_i}{\hat{P}_i^\alpha \hat{r}_i^{1-\alpha}} \right)^{1-\phi}. \end{aligned}$$

The second line follows from the results of Proposition 4.

To replace \hat{P}_i combine equations (4) and (5) to get

$$P_i = \left(\gamma \pi_{ii}^{\frac{1}{\theta}} \varphi^{-1} w_i^\beta r_i^\eta \right)^{\frac{1}{\beta+\eta}}.$$

Taking ratios,

$$\hat{P}_i = \hat{\pi}_{ii}^{\frac{1}{\theta(\beta+\eta)}} \hat{w}_i^{\frac{\beta}{\beta+\eta}} \hat{r}_i^{\frac{\eta}{\beta+\eta}}.$$

Next, taking ratios of equation (12)

$$\hat{r}_i = \hat{w}_i \hat{\lambda}_i \hat{\Omega}_{1i},$$

and so

$$\hat{P}_i = \hat{\pi}_{ii}^{\frac{1}{\theta(\beta+\eta)}} \hat{w}_i \hat{\lambda}_i^{\frac{\eta}{\beta+\eta}} \hat{\Omega}_{1i}^{\frac{\eta}{\beta+\eta}}$$

Combining \hat{P}_i and \hat{r}_i with the expression for \hat{U}_i above,

$$\begin{aligned}\hat{U}_i &= \hat{f}_i \left(\frac{1}{\hat{\pi}_{ii}^{\frac{\alpha}{\theta(\beta+\eta)}} \hat{\lambda}_i^{1-\alpha+\frac{\alpha\eta}{\beta+\eta}} \hat{\Omega}_{1i}^{1-\alpha+\frac{\alpha\eta}{\beta+\eta}}} \right)^{1-\phi}, \\ &= \hat{\pi}_{ii}^{-\frac{\alpha(1-\phi)}{\theta(\beta+\eta)}} \hat{\lambda}_i^{-\frac{(1-\phi)(\beta+\eta-\alpha\beta)}{\beta+\eta}} \hat{\Omega}_{2i}^{\frac{(1-\phi)(\beta+\eta-\alpha\beta)}{\beta+\eta}},\end{aligned}$$

where $\hat{\Omega}_{2i} = \hat{\Omega}_{1i}^{-1} \hat{f}_i^{\frac{\beta+\eta}{(1-\phi)(\beta+\eta-\alpha\beta)}}$ and was defined in Section 3.4. ■