Terms of Trade and Global Efficiency Effects of Free Trade Agreements, 1990-2002 *†

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March 1, 2011

Abstract

This paper infers the terms of trade effects of Free Trade Agreements (FTA's) using the structural gravity model. Recent research resolves two way causality problem between trade and FTA's, demonstrating large shifts of aggregate trade toward member countries relative to non-members. Using the same methods we estimate direct FTA effects on bilateral trade in 2 digit manufacturing goods from 1990-2002, calculate their incidence on consumers and producers in member and non-member countries, and from these construct a multi-dimensional (country, commodity, and time) set of terms of trade indexes for 40 countries plus a rest-of-the-world aggregate. There are significant gainers and some losers. Overall, for each sector, there is a gain in global efficiency, demonstrated with a novel measure of the change in iceberg melting.

JEL Classification Codes: F13, F14, F16
Keywords: Free Trade Agreements, Gravity, Terms of Trade, Coefficient of Resource Utilization.

*We are grateful to Scott Baier, Jeff Bergstrand, Rick Bond, Joseph François, Tomohiko Inui, Paul Jensen, Vibhas Madan, Maria Olivero, Javier Reyes, and Costas Syropoulos for helpful comments and discussions. We also thank participants at the Western Economic Association Meetings 2009, the Fall 2009 Midwest International Trade Conference at Penn State, and the department seminar at Fordham University. All errors are ours only.

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Introduction

The proliferation of regional trade agreements in the 1990's alarmed many trade policy analysts and popular observers because countries excluded from the agreements can be harmed by terms of trade deterioration. The harm to outsiders can more than offset the terms of trade gains to partners, reducing the efficiency of the world trading system. This paper measures the terms of trade and global efficiency effects of 1990's trade agreements in 2 digit manufacturing sectors. The results are reassuring: some countries gain over 10%, a few lose a little and global efficiency rises 0.8% .

Theory gives great prominence to the terms of trade effects of trade agreements and simulation models illustrate the theory with numerical assessments of the effect of tariff changes on the terms of trade. But there is little empirical evidence on their importance, because terms of trade are notoriously hard to measure and there are difficult inference problems with sorting out causation. In contrast, there is an extensive empirical literature on the trade volume effects of Free Trade Agreements (FTA's) based on the gravity equation, with recent methodological improvements that make results of substantial effects credible.[1] Effects larger than explicable by tariff changes are plausible because FTA's may typically induce unobservable trade cost reductions alongside the formal tariff reductions that are the direct object of the agreement. How big might the terms of trade effects associated with these volume changes be?

This paper uses the structural gravity model to infer the terms of trade effects of 1990's FTA's from their estimated volume effects. A key general equilibrium force runs from FTA's to changing trade volumes to changes in multilateral resistance to changes in sellers' prices. Sellers' prices change inversely to sellers' incidence, measured by outward multilateral resistance. Buyers' prices move with buyers incidence measured by inward multilateral resistance. The change in the terms of trade, the ratio of the index of sellers' prices to the index of buyers' prices, is measured consistently with the underlying theory for each country in our data.

[1] Earlier results were suspect due to two way causality — FTA's increase trade but large trade induces FTA formation.

An intuitive and novel measure of global efficiency quantifies the iceberg melting metaphor. FTA's change trade flows and thus how much of the iceberg melts, averaged over all bilateral shipments in all sectors. Theory provides a consistent method of averaging, applying the distance function (Deaton, 1979), itself an application of Debreu (1951).[2]

Notable studies of the volume effects of FTAs include Frankel (1997), Magee(2003) and a series of papers by Baier and Bergstrand (2002, 2004, 2007). While the early findings on the effects of FTAs and trading blocs on bilateral trade flows were mixed,[3] the latest developments in the empirical literature deal effectively with two way causality, and show that trading blocs and free trade agreements have large positive *direct*[4] effects on the volume of aggregate bilateral trade between member countries relative to non-member countries.[5]

We extend this line of research by estimating the terms of trade effects of free trade agreements that entered into force during the period 1990-2002. In contrast to much of the empirical gravity literature but consistent with the literature on the effects of trade agreements, we focus on trade flows disaggregated by sector as well as by trading partner. We calculate the effect of FTAs on buyers' and sellers' incidence and the associated sellers' price changes in 40 separate countries and an aggregate region consisting of twenty four additional nations, at the 2-digit ISIC manufacturing level of aggregation.

The results show that the 1990's FTA's significantly increased real manufacturing income of most economies in the world. 10 out of the 40 countries had terms of trade gains greater than 5% while gains of 10% or more were enjoyed by Bulgaria, Hungary, Mexico and Poland. Losses were smaller than −0.25% and confined to countries that did

[2]We were tempted to add a subtitle to our paper: "Gravity with still more gravitas" echoing Anderson and van Wincoop (2003).

[3]For example, Bergstrand (1985) found insignificant European Community (EC) effects on bilateral member's trade and Frankel et al (1995) supported his findings. Frankel (1997) found significant Mercosur effects on trade flows but even negative EC effects on trade in certain years. Frankel (1997) also provides a summary of coefficient estimates of the FTA effects from different studies. Ghosh and Yamarik (2004) perform extreme-bounds analysis to support the claim that the FTA effects on trade flows are fragile and unstable.

[4]Direct effects do not take into account FTA effects on trade flows that are channeled through output and expenditures and their effects on multilateral resistance.

[5]Baier and Bergstrand (2007) find that, on average, a FTA induces approximately a 100% increase in relative bilateral trade between two member countries within ten years from their entry into force.

not enter into FTA's: Australia, China, Korea and Japan. We estimate a significant rise in the global efficiency of trade for each manufacturing sector (ranging from 0.13 percent for Paper Publishing products to 1.8 percent for Textiles) and an overall efficiency gain of 0.79%.

A NAFTA experiment reveals that Mexico benefits tremendously from NAFTA because most of its gains disappear if NAFTA is switched off. The US and Canada lose too, but much less. Without NAFTA however, the US and Canada would have lost from the FTA movements in the rest of the global economy. Taken seriously and together the results imply that the competitive regionalization of the 1990's was essentially liberalizing.

Terms of trade changes measured here are impact effects that will shift further in a full general equilibrium analysis. For each country and sector, the total production is fixed (i.e., all factors are sector-specific), while for each country we ignore the income effects of net revenue or rent changes due to the change in trade policy. Non-manufactured goods are suppressed. The technology assumptions allow us to avoid having to build a complete general equilibrium model, which would require taking a stand on specification and parameter estimation of many dubious structural components. Standard implications of substitution imply that our estimates are lower bounds of the real income gains from FTA's via terms of trade effects. The no rent assumption avoids having to model many unobservable rents while the observable tariff revenue changes are a very small part of the income changes, as discussed further in Section 1.

Section 1 presents the theoretical foundation. Section 2 discusses the estimation of the gravity equation and the trade volume effect of FTA's and presents the terms of trade and global efficiency measures that result from switching on the FTA's of the 1990's in the base year 1990. Section 3 concludes with some suggestions for further research.

1 Theoretical Foundation

We seek reasonable inference of the terms of trade changes induced by free trade agreements. The theoretical foundation of the structural gravity model is chosen because gravity explains bilateral trade flows best, including the effect of free trade agreements on the volume of trade. We lean heavily on structural gravity theory to infer terms of trade changes from the volume change implications of FTA changes.[6]

To avoid taking a stand on many features of the economy that are difficult to model convincingly, we assume each country has an endowment vector of the goods for which we have data. We thus suppress non-traded goods and any substitutability in supply. Moreover, we assume that all goods are final, suppressing intermediate inputs.[7]

For further simplicity, we assume that no rents are associated with trade flows. All trade costs and their changes are treated as 'real' in our setup. Thus we suppress tariff revenues (which indeed are small for most goods and countries), quota rents (which are large for some country pairs and product lines but notoriously hard to measure) and monopoly rents associated with various trade barriers both formal and especially informal. This procedure departs substantially from the theoretical literature on the welfare effects of trade agreements, where the changes in rents play a key role.[8] We do not believe that rents and their changes are unimportant, but we do think that tariff revenues and their changes are a small part of the rents and the non-tariff rents are extremely difficult to measure. Efforts in this direction would distract from our focus on the terms of trade without much assurance of being more realistic.

Goods are differentiated by place of origin within each goods class. Each goods class forms a weakly separable group in demand with a Constant Elasticity of Substitution

[6] Anderson and Yotov (2010b) show that structural gravity comes remarkably close to accurately representing the data.

[7] Intermediates can be introduced with no change in the results if all sectors combine the material input with a primary factor endowment in a common proportion. This spurious added realism is dispensed with for simplicity.

[8] See Anderson and van Wincoop (2002) for treatment of tariff revenue changes combined with terms of trade changes in gravity model based simulation of NAFTA's effects. Terms of trade changes are far more important in the welfare effects than are the revenue changes. That study points out that gravity does a far better job of predicting the actual bilateral trade flow changes than did any of the CGE models surveyed.

(CES) aggregator that is identical across countries. On the supply side, goods from origin i, $i = 1, ..., N$, in class k, $k = 1, ..., K$, shipped to each destination j, $j = 1, ..., N$ are perfect substitutes. Consumer preferences at the upper, inter-sectoral, level are represented by a Cobb-Douglas utility function, which translates into constant expenditure shares such that total expenditures on goods from class k in country i are $E_i^k = \alpha_k Y_i$, where α_k, $\sum_k \alpha_k = 1$, is an expenditure share parameter (common across countries), and $Y_i = \sum_k Y_i^k$ is i's total Gross Domestic Product (GDP).

The preference and technology assumptions together with iceberg trade costs (distribution uses resources in the same proportion as production) imply trade separability: sellers' prices and consumer expenditures are affected only by the aggregate incidence of trade costs in each sector, independent of the details of the distribution of sales or purchases across trading partners. Buyers' incidence falls on consumer prices while sellers' incidence falls on factory-gate prices.

1.1 Structural Gravity

Conditional on the values of production and expenditure from the upper level, the lower level gravity equilibrium determines the value of bilateral shipments at end user prices, X_{ij}^k, between each origin-destination pair for each class of goods. Lower level consumer preferences are approximated by a globally common CES sub-utility function:

$$\left\{ \sum_i \beta_i^{k\, \frac{1-\sigma_k}{\sigma_k}} c_{ij}^{k\, \frac{\sigma_k - 1}{\sigma_k}} \right\}^{\frac{\sigma_k}{\sigma_k - 1}} \tag{1}$$

where, c_{ij} is the quantity consumed in destination j of goods in class k imported from origin i; σ_k is the elasticity of substitution for goods' class k;[9] and β_i^k is a CES share parameter. Consumers maximize (1) subject to series of budget constraints for each goods class:

$$\sum_i p_{ij}^k c_{ij}^k = E_j^k, \qquad \forall k,$$

[9]Recent developments in the empirical trade literature suggest that the elasticity of substitution varies across countries. See Broda et al (2006). In the empirical analysis however, we allow the elasticity to vary across countries.

where, E_j^k is total expenditure on goods from class k in country j (determined at the upper level equilibrium), p_{ij}^k is the price of origin i goods from class k for region j consumers, and $p_{ij}^k = p_i^{*k} t_{ij}^k$, where $t_{ij}^k \geq 1$ denotes the variable trade cost factor on shipment of goods in class k from i to j, and p_i^{*k} is the factory-gate price at i.

Solving the consumer's problem obtains the expenditures on goods of class k shipped from origin i to destination j as:

$$X_{ij}^k = (\beta_i^k p_i^{*k} t_{ij}^k / P_j^k)^{(1-\sigma_k)} E_j^k. \tag{2}$$

$P_j^k = [\sum_i (\beta_i^k p_i^{*k} t_{ij}^k)^{1-\sigma_k}]^{1/(1-\sigma_k)}$ is a CES price index and subsequently will be interpreted as buyers' incidence of trade costs.

Now consider the supply side and market clearance. The iceberg trade cost metaphor implies that we can treat the value of shipments at end user prices, Y_i^k for country i and goods class k, as the product of the price at the factory gate p_i^{*k} times the endowment q_i^k, some of which is used up in getting to the end users. On any particular origin-destination pair, for every unit shipped from i to j, only $1/t_{ij}^k < 1$ arrives at destination. $Y_i^k = p_i^{*k} q_i^k$ because end users must pay for the distribution costs.

Impose market clearance (at delivered prices) for goods in each class from each origin:

$$Y_i^k = \sum_j (\beta_i^k p_i^{*k})^{1-\sigma_k} (t_{ij}^k / P_j^k)^{1-\sigma_k} E_j^k, \qquad \forall k. \tag{3}$$

Define $Y^k \equiv \sum_i Y_i^k$ and divide the preceding equation by Y^k to obtain:

$$(\beta_i^k p_i^{*k} \Pi_i^k)^{1-\sigma_k} = Y_i^k / Y^k, \tag{4}$$

where $\Pi_i^k \equiv \sum_j (t_{ij}^k / P_j^k)^{1-\sigma_k} E_j^k / Y^k$.

The derivation of the structural gravity model is completed using (4) to substitute for

$\beta_i^k p_i^{*k}$ in (2), the market clearance equation and the CES price index. Then:

$$X_{ij}^k = \frac{E_j^k Y_i^k}{Y^k} \left(\frac{t_{ij}^k}{P_j^k \Pi_i^k} \right)^{1-\sigma_k} \quad (5)$$

$$(\Pi_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k} \right)^{1-\sigma_k} \frac{E_j^k}{Y^k} \quad (6)$$

$$(P_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k} \right)^{1-\sigma_k} \frac{Y_i^k}{Y^k}. \quad (7)$$

(5) is the structural gravity equation. Π_i^k denotes outward multilateral resistance (OMR), while P_j^k denotes inward multilateral resistance (IMR).

Outward multilateral resistance consistently aggregates all bilateral trade costs for the producers of each class of goods from each country into sellers' incidence. It is as if each country i shipped its product k to a single world market facing supply side incidence of trade costs of Π_i^k. This follows from interpreting (4) as the market clearance condition for a hypothetical world economy where a single representative consumer purchases variety i in class k at price $p_i^{*k}\Pi_i^k$, understanding that the CES price index for this hypothetical consumer is conventionally equal to 1 due to summing (4) over i.

Equation (7) shows that inward multilateral resistance is constructed as a weighted average of all bilateral buyers' incidences t_{ij}^k/Π_i^k. It is as if each country j bought its vector of class k goods from a single world market facing demand side incidence of P_j^k.[10] Thus, the multilateral resistance indexes consistently aggregate bilateral trade costs (including FTA effects) and simultaneously decompose their incidence on consumers and producers in each country.

The equilibrium factory gate prices p_i^{*k} reflect the forces of supply and demand in the global economy and also the sellers' incidence of trade costs facing the entire global economy, channeled through sellers' incidence. Thus

$$p_i^{*k} = \frac{(Y_i^k/Y_k)^{1/(1-\sigma_k)}}{\beta_i^k \Pi_i^k}$$

[10] Anderson and van Wincoop (2004) show that if the actual set of bilateral trade costs were to be replaced by hypothetical numbers $\widetilde{t}_{ij}^k = P_j^k \Pi_i^k$, all budget constraints and market clearance conditions would continue to hold, so that no disturbance at the upper level general equilibrium would occur.

Due to (4), p_i^{*k} is decreasing in Π_i^k, a connection tying terms of trade effects of FTA's to the incidence analysis of the gravity model. In conditional general equilibrium with given Y_i^k's, the relationship is the simple inverse one given above: a fall in incidence raises factory gate prices one for one. But in general equilibrium Y_i^k/Y^k is also a function of the p^*'s and the solution for the p^*'s reflects supply and demand conditions and sellers' incidence in all markets simultaneously.

1.2 Incidence and Total Effects of Free Trade Agreements

The procedure in the existing literature for estimating FTA effects on bilateral trade flows is to account for the presence of free trade agreements in the definition of the unobservable trade costs, t_{ij}^k, in the structural gravity equation (5). For a generic good, we define:

$$t_{ij}^{1-\sigma} = e^{\beta_1 FTA_{ij} + \beta_2 \ln DIST_{ij} + \beta_3 BRDR_{ij} + \beta_4 LANG_{ij} + \beta_5 CLNY_{ij} + \beta_6 SMCTRY_{ij}}. \quad (8)$$

Here, FTA_{ij} is an indicator variable for a free trade agreement between trading partners i and j. $\ln DIST_{ij}$ is the logarithm of bilateral distance. $BRDR_{ij}$, $LANG_{ij}$ and $CLNY_{ij}$ capture the presence of contiguous borders, common language and colonial ties, respectively. Finally, $SMCTRY_{ij}$ is a dummy variable for internal trade.[11]

It is clear from system (5)-(7) that the *direct* effect of free trade agreements on bilateral trade flows, measured by β_1 in (8), is only a fraction of the *total* FTA impact, which includes two additional indirect effects. The first additional FTA effect is channeled through the multilateral resistance terms. For given output and expenditures, system (14)-(15) maps changes in bilateral trade costs to changes in the multilateral resistances. Consequently, (5) reveals that any MR changes will affect bilateral trade flows. The second indirect FTA effect on trade flows is channeled through output and expenditures, which enter (5) directly, but also are structural elements in the construction of the multilateral resistance indexes. This indirect effect requires accounting for the FTA-driven changes in output and expenditures at the upper level equilibrium. In sum, in order to

[11] See Anderson and van Wincoop (2004) for an exhaustive discussion on trade costs.

estimate *total* FTA effects, one has to estimate FTA impact through the multilateral resistances and through changes in output and expenditures, in addition to the direct FTA effects on bilateral trade costs. We describe such a comprehensive procedure next.

As input to the evaluation, we estimate the t_{ij}^k's with and without the FTA imposed with panel methods. We take the initial year, pre-FTA, and choose units such that $p_i^{*k} = 1, \forall i, k$. This implies that the endowments are observed from the initial Y_i^k's. We then solve the market clearance equations (11) given below for the implied distribution parameters $\beta_i^k, \forall i, k$. Due to homogeneity, the distribution parameters are only identified up to a normalization, chosen here as $\sum_i (\beta_i^k)^{1-\sigma_k} = 1$.

To calculate the full effect of FTA's we conduct the counter-factual experiment of putting the FTA effect (using the t_{ij}^K's from later years) into the base year with fixed endowments. We find the set of factory gate prices and inward and outward multilateral resistances that results. The elasticity parameters are taken from estimates of Broda et al. (2006). They are required to solve the market clearance equation for prices, while not being needed for the estimated volume effects of FTA's. Once we know the p^*'s we can generate the Y's, the expenditures (E's) and the incidence variables, the P's and Π's. The level of the incidence variables is subject to the normalization of the β_I^k's, but their proportional change is invariant to to the normalization.

The supply shares under this setup are given by

$$\frac{Y_i^k}{Y^k} = \frac{p_i^{*k} q_i^k}{\sum_i p_i^{*k} q_i^k}, \forall i, k \tag{9}$$

for each sector and country. There are NK of these equations. The demand shares are given by

$$\frac{E_j^k}{Y^k} = \frac{\sum_k p_j^{*k} q_j^k}{\sum_{k,j} p_j^{*k} q_j^k}, \forall j, k. \tag{10}$$

This expression for the demand share uses the assumption that upper level preferences are characterized by Cobb-Douglas identical share parameters together with a balanced trade assumption that expenditure equals income, hence $E_j^k = \alpha_k \sum_k p_j^{*k} q_j^k$. Aggregate sales of k in the world equal aggregate expenditure from all destinations j, yielding equation

(10).

There are NK p^*'s that change from their initial value equal to 1 when the t's change due to the FTA experiment. They are solved from the market clearance equations, given the β's and q's.

$$\frac{p_i^{*k} q_i^k}{\sum_i p_i^{*k} q_i^k} = \sum_j (\beta_i^k p_i^{*k} t_{ij}^k / P_j^k)^{1-\sigma_k} \frac{\sum_k p_j^{*k} q_j^k}{\sum_{j,k} p_j^{*k} q_j^k}, \forall i, k \tag{11}$$

where

$$(P_j^k)^{1-\sigma_k} = \sum_i (\beta_i^k p_i^{*k} t_{ij}^k)^{1-\sigma_k}, \forall j, k \tag{12}$$

and (10) is utilized to replace E_j^k / Y^k on the right of the right hand side of (11).

There are NK equations in (11) and another NK in (12). As with any neoclassical market clearing conditions, a normalization of prices is required because the system is homogeneous of degree zero in the vector of factory gate prices. A natural normalization is one that holds world real resources constant:

$$Y^0 = \sum_{i,k} p_i^{*k} q_i^k. \tag{13}$$

The constant real resource implication of normalization (13) will be useful in simplifying the calculation of a world efficiency measure of the effect of free trade agreements. In the initial (base) year the Y_i^k's are observed, and with the choice of units, this means the endowments q_i^k are observed and $Y^0 = \sum_{i,k} q_i^k$. The normalization is thus

$$1 = \sum_{i,k} p_i^{*k} \frac{q_i^k}{\sum_i q_i^k},$$

interpreted as price deflation that maintains world 'real' resource use.

A special feature of (11)-(12), due to separability and homotheticity, is that only 2NK-K equations are linearly independent, so (13) must apply sector by sector in equilibrium. This may be seen as follows. Let $\mathbf{p}^{1k} \equiv \{p_i^{*k}\}$, denote the vector of equilibrium factory gate prices in sector k in some particular equilibrium with the new t's. At this equilibrium $\mathbf{p}^{1k}$, a scalar shift λ^k in $\mathbf{p}^k$ raises the P_j^k's equiproportionately. Then for the block of equations for sector k within (11), conditional on the initial equilibrium value of $\sum_k p_j^{*k} q_j^k / \sum_{i,k} p_i^{*k} q_i^k = \lambda^k \sum_k p_i^{1k} q_j^k / \sum_{i,k} q_i^k$ under the normalization (13), the equation block continues to hold. Consistency with the normalization (13) requires $\lambda^k = 1, \forall k$.

The incidence of the trade cost changes is implied by the multilateral resistance system:

$$(\Pi_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} \frac{E_j^k}{Y^k}, \forall k, i \tag{14}$$

$$(P_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}.\right)^{1-\sigma_k} \frac{Y_i^k}{Y^k}, \forall j, k \tag{15}$$

In practice, since the P's are already solved for from (11)-(13), the Π's are solved recursively using the solution P's in (14). This solution is consistent with solving (14)-(15) for the supply and expenditure shares implied by the solution p^*'s and normalizing the Π's by

$$\sum_i (\beta_i^k)^{1-\sigma_k} (p_i^{*k} \Pi_i^k)^{1-\sigma_k} = 1, \forall k. \tag{16}$$

(16) arises from interpreting the global sales pattern $\{Y_i^k / Y^k\}$ as arising from sales to a hypothetical 'world' consumer with CES preferences, resulting in $Y_i^k / Y^k = (\beta_i^k p_i^{*k} \Pi_i^k)^{1-\sigma_k}$ where the hypothetical CES global price index is equal to 1.

1.3 National Efficiency Measures

Accounting for the effect of trade cost changes on national efficiency in this setup is very simple.[12] For each good in each country, there is a 'factory gate' price (unit cost of production and distribution) p_i^{*k} in country i and product k, and there is a consumer price index P_i^k that indexes the prices of all varieties j in product class k.

National product of the affected part of the economy with multiple goods is given by

[12] We follow a procedure similar to Anderson and van Wincoop (2002) in their analysis of NAFTA. They use a single aggregate good whereas our model is disaggregated. But the endowment economy structure is similar. A more significant difference is that Anderson and van Wincoop use 'tariff multipliers' to construct the standard welfare measures of trade liberalization and pretend to a full general equilibrium analysis, whereas here the tariff multiplier is suppressed to focus only on the terms of trade effects (which were by far the biggest part of the story in Anderson and van Wincoop's NAFTA analysis).

$\sum_k p_i^{*k} q_i^k$. Deflating by the consumer 'true cost of living' index $C_i = \exp(\sum_k \alpha_k \ln P_i^k)$ gives a real income measure:

$$R_i = \sum_k p_i^{*k} q_i^k / C_i = \sum_k q_i^k \frac{\sum_k p_i^{*k} q_i^k / \sum_k q_i^k}{C_i}. \tag{17}$$

The second equation means that real income R_i under the normalization (13) is equal to i's real product $\sum_k q_i^k$ times i's terms of trade

$$T_i = \frac{\sum_k p_i^{*k} q_i^k / \sum_k q_i^k}{C_i}. \tag{18}$$

The terms of trade given by (18) is the ratio of the Laspeyres price index of exportable goods to the true cost of living index of importable goods, satisfying the standard definition with functional forms that are exact under our assumptions.

The effect on real income in country i from a switch from No FTA (denoted with superscript 0) to FTA (denoted with superscript F) can be evaluated by computing the proportional real income change with the ratio R_i^F / R_i^0, equal to the proportionate change in the terms of trade T_i^F / T_i^0.

1.4 World Efficiency Measures

World efficiency can be evaluated by further exploiting implications of the structural gravity model. The iceberg melting metaphor is extended to a scalar aggregate using the interpretation of outward multilateral resistance as aggregate sellers incidence and inward multilateral resistance as buyers' incidence. Global aggregate sellers' incidence is interpreted as global aggregate shrinkage due to 'melting' prior to arrival on the 'world' market. Global aggregate buyers' incidence is interpreted as the further melting due to shipment from the 'world' market to its various destinations. The idea is isomorphic to Debreu's (1951) coefficient of resource utilization, providing a very natural measure of the FTA-induced change in the global efficiency of distribution.

The endowment of world resources is the vector $\{q^k \equiv \sum_i q_i^k\}$. In equilibrium, only a fraction of the endowment arrives at the hypothetical 'world' market for sellers to exchange with buyers because some melts away in shipment to the 'world' market. A further nationally varying fraction melts away as the buyers ship their 'world' market purchases to their destinations. The aggregate sellers (across origins) and buyers (across destinations) melting fractions for each goods class k are derived utilizing structural gravity and the CES preference structure. A further aggregation across the goods classes is derived based on the Cobb-Douglas preference structure of the upper level preferences.

Consistent aggregation of sellers' incidence across sources in each goods class k follows from defining the global aggregate sellers' incidence: Π^k by:

$$\Pi^k \left(\sum_i (\beta_i^k p_i^{*k})^{1-\sigma_k} \right)^{1/(1-\sigma_k)} = \left(\sum_i (\beta_i^k p_i^{*k} \Pi_i^k)^{1-\sigma_k} \right)^{1/(1-\sigma_k)} = 1. \tag{19}$$

The rightmost equality follows from the normalization (16) of the hypothetical equilibrium: the hypothetical consumer price index for class k goods for the 'world' consumer (i.e., the consumer located in the 'world' market) is equal to 1. Π^k is a CES function of the Π_i^k's, the (variable) weights being the hypothetical frictionless equilibrium world shares

$$w_i^k = \frac{(\beta_i^k p_i^{*k})^{1-\sigma_k}}{\sum_i (\beta_i^k p_i^{*k})^{1-\sigma_k}}. \tag{20}$$

Re-writing (19) using (20), the CES aggregator in terms of power transforms is

$$(\Pi^k)^{1-\sigma_k} = \sum_i w_i^k (\Pi_i^k)^{1-\sigma_k}, \tag{21}$$

where the weights are given by (20).

The first expression on the left hand side of (19) is the product of the aggregate incidence Π^k and the hypothetical frictionless equilibrium price index. Exploiting the second equality in (19), the global sales can be interpreted as the product of effective world consumption q^k/Π_k and the frictionless price index $\left(\sum_i (\beta_i^k p_i^{*k})^{1-\sigma_k}\right)^{1/(1-\sigma_k)}$. This is the iceberg melting metaphor in the aggregate.

In the initial situation (without FTA's for example) the factory gate prices in (19) are all equal to one, yielding aggregate sellers incidence Π^{k0}. Bringing in the new trade costs (the FTA's) induces new p^*'s and new Π's, and hence new aggregate effective consumption. Let Π^{kF} denote the value of Π^k in the FTA equilibrium. For each goods class, the effect of the FTA on global efficiency via the sellers' incidence is measured by Π^{k0}/Π^{kF}.

On the buyers' side of the market, goods are in effect purchased on the 'world' market in the total amount q^k/Π^k. For each destination j the goods are shipped home with further melting such that only E_j^k/P_j^k arrives at destination j. Or, effectively the buyer covers the full margin $\Pi^k P_j^k$. To aggregate across destinations the global average buyers incidence is defined by

$$\frac{1}{P^k} \equiv \sum_j \frac{E_j^k}{Y^k} \frac{1}{P_j^k}. \tag{22}$$

Then world consumption at destination is given by

$$\frac{q^k}{\Pi^k P^k}, \tag{23}$$

the world endowment of good k is deflated by the product of the appropriate average buyers and sellers incidence.

A scalar measure of the overall efficiency gain requires some sort of weighting across goods classes making use of the hypothetical world market and the identical preferences across goods classes. With Cobb-Douglas preferences the world efficiency measure is defined by

$$\frac{1}{\Pi P} = \frac{1}{\exp[\sum_k \alpha_k (\ln \Pi^k + \ln P^k)]}. \tag{24}$$

Evaluating ΠP at initial and FTA trade costs and forming their ratio $\Pi^0 P^0/\Pi^F P^F$ gives a scalar measure of the global efficiency gain from the shift in trade costs due to the FTA. It should be emphasized that the hypothetical consumption rays generated in this way are not proportional to any single country's effective consumption ray, so that (24) is not a measure of social welfare for the world economy.

Figure 1 illustrates (24) for the case of two goods classes. E is the endowment point. The line with slope equal to minus 1 through E denotes the initial value of the world endowment. Point C denotes the initial equilibrium effective consumption point

$q^1/\Pi^{1,0}, q^2/\Pi^{2,0}$. The iso-utility contour through point C gives all consumption vectors c^1, c^2 satisfying $u(c^1, c^2) = u(q^1/\Pi^{1,0}, q^2/\Pi^{2,0}) = u^0$. The efficiency of the initial equilibrium is given by the radial contraction along ray OE from E to point A that gives the same level of utility as the actual effective consumption at C. Thus $1/\Pi = OA/OE$. Point F denotes the FTA equilibrium effective consumption $q^1/\Pi^{1F}, q^2/\Pi^{2F}$. The iso-utility contour associated with point F cuts ray OE at D, with efficiency measure OD/OE. The proportionate efficiency change is OD/OA.

Figure 1.World Efficiency Measurement

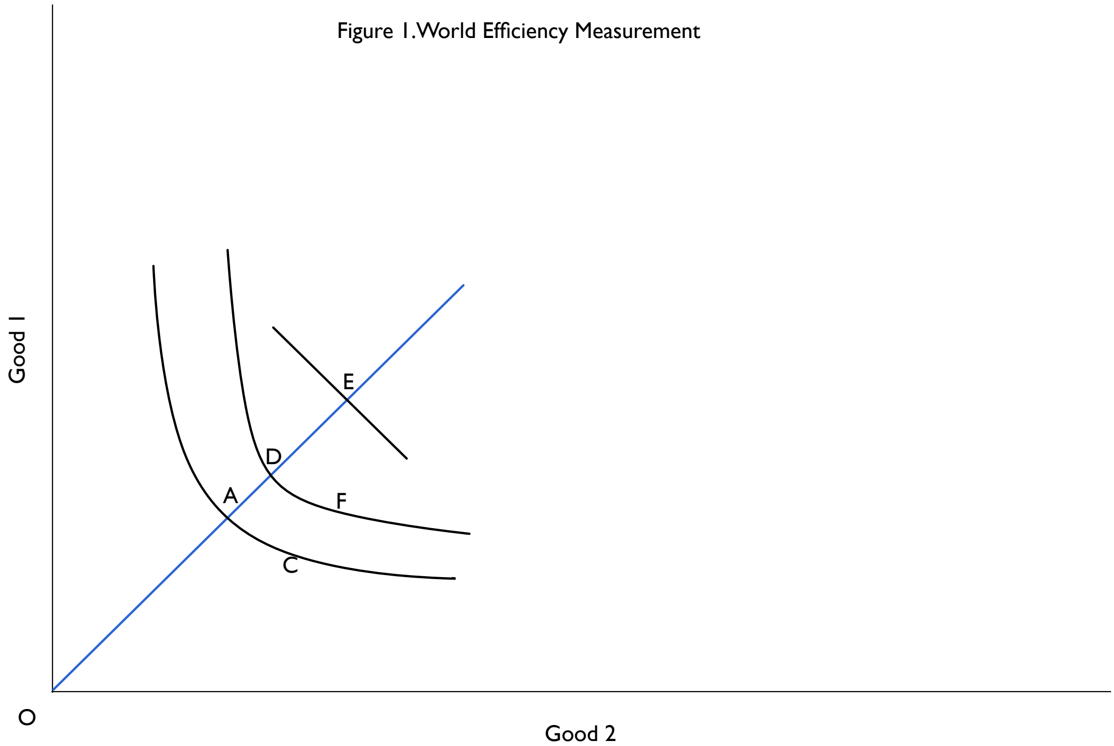

Figure 1 also illustrates the global efficiency measure on the sellers side for each goods class, reinterpreting the goods as varieties within a goods class and the iso-utility contours as sub-utility contours, understanding that they have CES structure instead of Cobb-Douglas. The effect of the FTA-induced change in the factory gate equilibrium prices p_i^{*k} shifts the weights in (21) as well as each country's sellers' incidence Π_i^k. Both with a goods class and between goods classes, the aggregator is an application of the distance function (Deaton, 1979), derived from Debreu (1951).

2 Empirical Implementation and Analysis

2.1 Econometric Specification

The econometric specification of gravity is completed by substituting (8) for t_{ij} into (5) and then expanding the gravity equation with a multiplicative error term, ϵ_{ij}^k:

$$X_{ij}^k = \frac{Y_i^k E_j^k}{Y^k} \left(\frac{t_{ij}^k}{\Pi_i^k P_j^k} \right)^{1-\sigma_k} \epsilon_{ij}^k. \tag{25}$$

To obtain econometrically sound estimates of the parameters of interest from equation (25), we address the following challenges: presence of zero trade flows; heteroscedasticity in trade flows data; endogeneity of free trade agreements; and, unobservable multilateral resistance terms. To utilize the information carried by the zero trade flows and to account for heteroskedasticity in trade flows data, we resort to the Poisson pseudo-maximum-likelihood (PPML) estimator advocated by Santos-Silva and Tenreyro (2007) who argue that the truncation of trade flows at zero biases the standard log-linear OLS approach. In addition, they show that not accounting for heteroscedasticity in the log-linear OLS regressions produces inconsistent coefficient estimates.[13]

The issue of FTA endogeneity is not new to the trade literature (see Trefler 1993, for example). However, primarily due to the lack of reliable instruments, standard instrumental variable (IV) treatments of endogeneity in cross-sectional settings have not been successful in addressing the problem.[14] To account for FTA endogeneity, we resort to the panel data estimation techniques described in Wooldridge (2002) and first applied to a similar setting by Baier and Bergstrand (2007), who employ aggregate data to show that direct FTA effects on bilateral trade flows can be consistently isolated in a theoretically-founded gravity model by using country-pair fixed effects. Alternatively,

[13] Helpman, Melitz and Rubinstein (2008) (HMR) propose an alternative approach. They develop a formal model of selection to account for the zero trade flows, where exporters must absorb some fixed costs to enter a market. They use religion as an exogenous variable that enters selection but is excluded from determination of the volume of trade.

[14] See for example Magee (2003) and Baier and Bergstrand (2002, 2004b). Baier and Bergstrand (2007) summarize the findings from these studies as "at best mixed evidence of isolating the effect of FTAs on trade flows."

Baier and Bergstrand (2007) argue that consistent FTA estimates can be obtained with first-differenced panel data, which eliminates the pair fixed effects.

Following the developments in the empirical gravity literature, we use time-varying, directional (source and destination), country-specific dummies to control for the multilateral resistances.[15] Taking all of the above considerations into account, we use the PPML technique to estimate the following econometric specification for each class of commodities in our sample:

$$X_{ij,t} = \exp[\beta_0 + \eta_{i,t} + \theta_{j,t} + \gamma_{ij} + \beta_1 FTA_{ij,t} + \beta_2 FTA_{ij,t-1} + \beta_3 FTA_{ij,t-2} + \epsilon_{ij,t}], \qquad \forall k. \quad (26)$$

Here, X_{ij} is bilateral trade (in levels) between partners i and j at time t.[16] $FTA_{ij,t}$ is an indicator variable that takes a value of one if at time t countries i and j are members of the same free trade agreement. $\eta_{i,t}$ denotes the time-varying source-country dummies, which we use to control for the outward multilateral resistances. $\theta_{j,t}$ encompasses the dummy variables that account for the inward multilateral resistances. γ_{ij} captures the country-pair fixed effects used to address FTA endogeneity.

Following Baier and Bergstrand (2007) we allow for gradual entering into force (phasing-in) of the free trade agreement effects by including FTA lags in specification (26). From an economic point of view, such an approach is reasonable because it may take time for the exporting countries to adjust to the new economic conditions under a recently implemented FTA. From an econometric perspective, this procedure will add a time dimension (in addition to the commodity, country, and producer and consumer dimensions) to the

[15] Anderson and van Wincoop (2003) use custom programming to account for the multilateral resistances in a static setting. Feenstra (2004) advocates the directional, country-specific fixed effects approach. To estimate the effects of the Canadian Agreement on Internal Trade (AIT), Anderson and Yotov (2010a) use panel data with time-varying, directional (source and destination), country-specific fixed effects. Olivero and Yotov (2011) formalize their econometric treatment of the MR terms in a dynamic gravity setting.

[16] In a static setting, (5) implies that income and expenditure elasticities of bilateral trade flows are unitary and, therefore, size-adjusted trade is the natural dependent variable. Bringing output and expenditures on the left-hand side has the additional advantage of controlling for endogeneity of these variables. Using aggregate data however, Frankel (1997) shows that the bias due to GDP endogeneity is insignificant. In addition, Olivero and Yotov (2011) show that income and expenditure elasticities are not necessarily equal to one in a dynamic setting, such as the one that we employ here to account for FTA endogeneity. Thus, in addition to accounting for the unobserved multilateral resistances, the fixed effects in our estimations will also absorb country-specific output and expenditures.

data sets of welfare effects that we will construct in the next section.

Finally, as noted by Cheng and Wall (2005), "Fixed-effects estimations are sometimes criticized when applied to data pooled over consecutive years on the grounds that dependent and independent variables cannot fully adjust in a single year's time." To avoid this critique, we use only the years 1990, 1994, 1998, and 2002. This implies that $FTA_{ij,t-1}$ and $FTA_{ij,t-2}$ are four-year and eight-year lags, respectively.

2.2 Data Description

This study covers the period 1990-2002 for a total of 41 trading partners including 40 separate countries and the rest of the world (ROW), consisting of 24 additional nations.[17] None of the countries included in ROW are part of any FTAs with countries in the main sample during the period of investigation. There are four nations however (Australia, China, Japan, and South Korea), that are treated separately, even though they did not enter any FTA between 1990 and 2002. We use these countries (outsiders), along with the aggregate ROW region, to gauge FTA effects on non-members. The commodities covered include manufacturing production classified according to the United Nations' 2-digit International Standard Industrial Classification (ISIC) Revision 2.[18]

To estimate gravity and to calculate the indexes of interest, we use industry-level data on bilateral trade flows and output, and we construct expenditures, subject to our structural model, for each trading partner and each commodity class, all measured in

[17]The 40 countries are Argentina, Australia, Austria, Bulgaria, Belgium-Luxembourg, Bolivia, Brazil, Canada, Switzerland, Chile, China, Columbia, Costa Rica, Germany, Denmark, Ecuador, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Iceland, Israel, Italy, Japan, Korea, Rep., Mexico, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Sweden, Tunisia, Turkey, Uruguay, United States. The rest of the world includes Cameroon, Cyprus, Egypt Arab Rep., Hong Kong, Indonesia, India, Iran Islamic Rep., Jordan, Kenya, Kuwait, Sri Lanka, Macao, Malta, Myanmar, Malawi, Malaysia, Niger, Nepal, Philippines, Senegal, Singapore, Trinidad and Tobago, Tanzania, South Africa.

[18]The nine 2-digit ISIC manufacturing categories are (short labels, used for convenience throughout the paper, are reported in parentheses): 31. Food, Beverages, and Tobacco Products (Food); 32. Textile, Apparel, and Leather Products (Textile); 33. Wood and Wood Products (Wood); 34. Paper and Paper Products (Paper); 35. Chemicals, Petroleum, Coal, Rubber, and Plastic Products (Chemicals); 36. Other Non-metallic Products (Minerals); 37. Basic Metal Industries (Metals); 38. Fabricated Metal Products, Machinery, Equipment (Machinery); 39. Other manufacturing. Inspection of the output data at the 3-digit and 4-digit ISIC level of aggregation reveals that many countries report Equipment production, and especially Scientific Equipment production, under the category Other Manufacturing. Therefore, to avoid inconsistencies, we combine the last two 2-digit categories into one, which we label Machinery.

thousands of current US dollars for the corresponding year.[19] In addition, we use data on bilateral distances, contiguous borders, colonial ties, common language, elasticity of substitution, and the presence of regional free trade agreements. Table 1 reports summary statistics for the main estimation variables (described below) for the first and the last year in the sample.[20]

Data sources and all variables employed in our estimations and analysis are presented in the Data Appendix. Here, we just describe the two data sources that we use to construct the main explanatory variable, an indicator regressor capturing the presence of FTAs. Most of the data are from the FTA dataset constructed by Baier and Bergstrand (2007), which we update with data on some additional agreements and years from the World Trade Organization (WTO) web site.[21] Following Baier and Bergstrand (2007), we only consider full FTAs and customs unions that entered into force during the period of investigation, 1990-2002. Table 2 lists the trade agreements included in our sample in chronological order.

2.3 Gravity Estimation Results

Panel PPML estimates of equation (26), obtained with bilateral dummies and time-varying, directional, fixed effects, and accounting for FTA phasing in, are reported in Table 3. Several properties stand out. Free trade agreements have positive, and economically and statistically significant impact on bilateral trade flows between member countries.[22] As expected, we do observe phasing-in of the FTA effects, which are spread

[19]Baldwin and Taglioni (2006) discuss in length the implications of inappropriate deflation of nominal trade values, which they call "the bronze-medal mistake" in gravity estimations. Their most preferred econometric specification is one with un-deflated trade values, bilateral fixed effects, and time-varying country dummies, which, in addition to accounting for the multilateral resistances in a dynamic setting, will "also eliminate any problems arising from the incorrect deflation of trade." The structural interpretation of the time-varying, country-specific, directional fixed effects (FEs) in our setting is a combination of the multilateral resistance terms and the trading partners output and expenditures. It is easy to see how the FEs would also absorb any deflator indexes, exchange rates, etc. Thus, the real- and nominal-trade estimates should be identical.

[20]Descriptive statistics for all variables as well as the data set itself are available by request.

[21]The data from Baier and Bergstrand (2007) can be accessed at the author's web sites *http : //www.nd.edu/ jbergstr/* and *http : //people.clemson.edu/ sbaier/*, respectively. The WTO data is available at $http://www.wto.org/english/tratop_e/region_e/summary_e.xls$.

[22]'Paper and Paper Products' is the only category for which the initial FTA effect is negative and statistically significant, however very small in magnitude.

relatively evenly over time.[23] The two exceptions are 'Wood and Wood Products' and 'Paper and Paper Products'. Allowing for phasing-in reveals that bilateral trade flows in these two categories require some time to adjust to the implementation of free trade agreements. In each case, the coefficient on the second four-year lag FTA dummy, L2.FTA, is positive and economically and statistically significant.[24]

Estimation results from Table 3 reveal that the FTA effects on bilateral trade at the commodity level are relatively persistent, however, there is no clear evidence of time trends. For some categories, such as 'Textile, Apparel, and Leather Products' and 'Food, Beverages, and Tobacco Products', there is a large initial effect followed by a gradual decrease. For other categories, such as 'Chemicals, Petroleum, Coal, Rubber, and Plastic Products', the initial FTA effect is relatively small and it increases over time. Finally, there is no clear time trend for 'Basic Metal Products' and 'Fabricated Metal Products, Machinery, and Equipment'. Estimates from row (3) of Table 3 indicate that, for most commodities, the FTA effects are still strong nine years after their entry into force. With one exception, all point estimates of L2.FTA, the second four-year lag of the FTA dummy, are positive and economically and statistically significant. The only exception (with positive but not statistically significant estimate) is 'Food, Beverages, and Tobacco'. This suggests that FTA effects for all or part of the products in this category are short-lived.

In the fifth row of Table 3, labeled "FTA_TOTAL", we report total FTA effects obtained by summing the values from the first three rows for each product. Standard errors for these numbers are obtained with the delta method. Without any exception, all estimates are positive and statistically significant. There is significant variability (within reasonable bounds) in the average treatment FTA effect across different products. The effect is weaker for commodity categories such as 'Wood and Wood Products', 'Paper

[23]These results are consistent with the findings from Baier and Bergstrand (2007), obtained with aggregate data.

[24]Panel estimates obtained without lags (available by request) reveal that 'Wood and Wood Products' and 'Paper and Paper Products' are the only two product categories for which the average FTA treatment effects over the whole period 1990-2002 are not significant. The fact that some average estimates show insignificant, while some of their phasing-in components are significant, reinforces our (and Baier and Bergstrand's,2007) preferred approach to allow for gradual FTA entering into force.

and Paper Products', and 'Non-metallic Products', and stronger for categories such as 'Textile, Apparel, and Leather Products', 'Basic Metal Industries', and 'Fabricated Metal Products, Machinery, and Equipment'. It is encouraging to note that the disaggregated estimates of the direct FTA effects are in line with the findings from related studies. Varying between 0.286 (for Wood) and 1.291 (for Textiles), our estimates are comparable to the FTA average treatment effect estimate of 0.46 from Baier and Bergstrand (2007) and to the ATE effect of 0.94 from Rose (2004). Both of the aforementioned studies use aggregate-level data and a sample of close to one hundred countries.

In order to obtain the general equilibrium FTA welfare effects of interest in this study, we need to construct bilateral trade costs t_{ij}'s, including *internal* trade costs t_{ii}'s. One direct possibility to proxy for the t_{ij}'s is to use the estimates of the bilateral fixed effects from specification (26) in combination with the FTA effects:

$$\hat{t}_{ij}^{1-\sigma} = e^{\hat{\beta}_{ij}+\hat{\beta}_{fta}FTA_{ij}+\hat{\beta}_{l.fta}L.FTA_{ij}+\hat{\beta}_{l2.fta}L2.FTA_{ij}}, \tag{27}$$

where $\hat{\beta}_{ij}$ is constructed by adding up horizontally the estimates of the country-pair fixed effects. $\hat{\beta}_{fta}$, $\hat{\beta}_{l.fta}$, and $\hat{\beta}_{l2.fta}$ are the estimates of the current, lagged, and two-period lagged FTA effects, respectively. This approach, however, will not obtain internal trade costs t_{ij}'s, as perfect collinearity does not allow for separate identification of the fixed effect estimates $\hat{\beta}_{ii}$'s for individual countries in model (26).[25] Therefore, we adopt an alternative, three-step procedure that allows us to simultaneously estimate bilateral trade costs as well as internal trade costs. First, we estimate the panel gravity model (26) using the PPML estimator with time-varying, source and destination fixed effects, but this time, instead of using bilateral fixed effects, we employ the standard time-invariant

[25] We do account for internal trade in our FTA estimates by including a single dummy variable for all countries. Another approach that simultaneously obtains consistent gravity estimates (that can be used to construct bilateral trade costs) and unbiased FTA estimates, is to regress the estimates of the bilateral fixed effects from (26) on the set of standard gravity variables. In analysis available by request, we improve on Cheng and Wall (2005) by using variance weighted least squares to obtain unbiased gravity estimates from the bilateral fixed effects. However, the same critique (not being able to identify internal trade costs separately for each country) applies for this approach as well. Nonetheless, we experimented with this method to find that the resulting bilateral trade costs (excluding internal trade costs) are very similar to the ones discussed below, which reinforces our confidence in the procedure we adopt to obtain our main results.

gravity covariates:[26]

$$X_{ij} = \exp[\tilde{\beta}_0 + \tilde{\beta}_1 FTA_{ij,t} + \gamma_1 \ln DIST_{ij} + \gamma_2 BRDR_{ij} + \gamma_3 LANG_{ij} + \gamma_4 CLNY_{ij} + \gamma_5 SMCTRY_{ij} + \tilde{\eta}_{i,t} + \tilde{\theta}_{j,t} + \varepsilon_{ij,t}]. \quad (28)$$

Then, we use the obtained estimates and actual data on the gravity variables to construct a complete set of power transforms of the bilateral trade costs that do not capture the presence of FTAs:

$$\left(\widehat{t}_{ij}^{NOFTA}\right)^{1-\sigma} = e^{\hat{\gamma}_1 \ln DIST_{ij} + \hat{\gamma}_2 BRDR_{ij} + \hat{\gamma}_3 LANG_{ij} + \hat{\gamma}_4 CLNY_{ij} + \hat{\gamma}_5 SMCTRY_{ij}}. \quad (29)$$

(29) is the standard procedure used in the literature to approximate bilateral trade costs. Finally, we add the FTA estimates from (26) to construct a set of bilateral trade costs that do account for FTA presence:[27]

$$\left(\widehat{t}_{ij}^{FTA}\right)^{1-\sigma} = \left(\widehat{t}_{ij}^{NOFTA}\right)^{1-\sigma} e^{\hat{\beta}_{fta} FTA_{ij} + \hat{\beta}_{l.fta} L.FTA_{ij} + \hat{\beta}_{l2.fta} L2.FTA_{ij}}. \quad (30)$$

Provided that the FTA estimates are unbiased (which is ensured by the panel data treatment) and that $\left(\widehat{t}_{ij}^{NOFTA}\right)^{1-\sigma}$ is a good proxy for the time-invariant trade costs (as we argue below), (30) is a valid representation of the FTA effects on bilateral trade costs.

Without going into details, we briefly interpret the estimates of (28), which are presented in Table 4.[28] Disaggregated gravity works well and our findings are as expected. Without any exception, all estimates of the effects of bilateral distance on bilateral trade flows are negative and significant at any level. The variability of the estimates across commodities is intuitive. Transportation costs is a natural explanation. Common borders facilitate trade. The estimates of the coefficients on BRDR are positive and significant at any level. Textiles Products are the only exception with an insignificant coefficient

[26]For brevity, phasing-in effects are not accounted for in this specification. Estimation results and their implications are virtually identical when lagged FTA dummies are introduced in (28).

[27]Below, we show that (28) produces unreliable (biased and even negative) FTA estimates.

[28]For a more thorough discussion on the disaggregated gravity estimates across a wider commodity sample see Anderson and Yotov (2010b).

estimate.

Overall, we find that language does not have a very strong effect on bilateral trade. The estimate of the coefficient on LANG is positive and significant for only half of the eight product categories. A possible explanation for this result is that over the past quarter of the century, English emerged as a universal international language. In contrast, the intuition behind the largest positive coefficient estimate (for Paper) is that this category includes 'Publishing products', whose consumption, naturally, requires knowledge of a particular language. The role of colonial ties in explaining bilateral trade flows has diminished too. Only five of the eight estimates are positive and significant. Using more disaggregated data, Anderson and Yotov (2010b) find even weaker evidence of the effects of colonial ties. The large, positive, and significant estimates on SMCTRY capture the well-documented home bias in trade. It makes intuitive sense, for example, that the estimate on Food is the largest of all.[29]

Finally, it is important to note that the estimates of the FTA effects from Table 4 vary in sign and significance. In fact, half of the eight estimates are negative, while only two are positive and significant as should be.[30] These findings are comparable to the cross-section aggregate estimates obtained with country fixed effects in Baier and Bergstrand (2007). Similarly to those authors, but this time on the basis of disaggregated panel estimations, we conclude that inappropriate econometric treatment of the FTA effects produces biased, unstable, and even negative estimates.

Overall, the results from Table 4 are convincing. Aggregate estimations with similar properties have been interpreted as strong evidence in support of gravity theory and

[29] It should be noted that while the controlling for internal trade has been ignored in the vast majority gravity estimates, the few studies that do include a variant of our $SMCTRY$ covariate always estimate large, positive and significant coefficient estimates on this dummy. For example, Wolf (2000) finds evidence of US state border effects using aggregate shipments data. In the case of Canadian commodity trade, Anderson and Yotov (2010a) find that internal provincial trade is higher than interprovincial and international trade for 19 non-service sectors during the period 1992-2003. In a complementary study, Anderson et al (2011) obtain similar estimates for Canadian service trade. Anderson and Yotov (2010b) find the same effects for 18 manufacturing sectors in the world (76 countries), 1990-2002. Finally, Jensen and Yotov (2011) estimate very large and significant $SMCTRY$ impact for important agricultural commodities in the world in 2001.

[30] Accounting for phasing-in of the FTAs produces similar results for the FTA estimates, and virtually identical estimates for the rest of the gravity variables. Standard gravity estimates obtained without controlling for FTA presence are not statistically different than the ones from Table 4.

used to construct aggregate bilateral trade costs. Similarly, the set of standard gravity covariates and the commodity level estimates derived here can be used to construct a reasonable measure of disaggregated bilateral trade costs. To further reinforce this argument, we estimate a very strong and significant positive correlation between the trade costs obtained with the standard gravity variables and the bilateral fixed effects estimates from equation (26).

2.4 Terms of Trade and Global Efficiency Effects of FTA's

The theory and inferred trade costs of preceding sections are now combined to calculate the effects of the FTAs that entered into force between 1990 and 2002. The effects on the sellers and the buyers (changes in the numerator and denominator of (17) respectively) in each country are analyzed separately. The two are combined to form the changes in the real purchasing power of manufacturing income. Finally, we present the global efficiency measures. Most of the indexes reported here are at the country- and commodity-level and are consistently aggregated from country-commodity pair numbers. The latter are available by request.

FTA Effects on Sellers. We use factory-gate prices, p^*'s, to measure FTA effects on producers.[31] To speed up the computational process, we calculate the indexes of interest iteratively. First we obtain the p^*'s by substituting (12) into (11) and solving:

$$\frac{p_i^{*k} q_i^k}{\sum_i p_i^{*k} q_i^k} = \sum_j \frac{(\beta_i^k p_i^{*k} t_{ij}^k)^{1-\sigma_k}}{\sum_i (\beta_i^k p_i^{*k} t_{ij}^k)^{1-\sigma_k}} \frac{\sum_k p_j^{*k} q_j^k}{\sum_{j,k} p_j^{*k} q_j^k}, \forall i, k. \tag{31}$$

(31) consists of NK-K independent equations and, as discussed earlier, in order to obtain a unique set of factory-gate prices, we impose K normalizations of the form $1 = \sum_{i,k} p_i^{*k} \frac{q_i^k}{\sum_i q_i^k}, \forall i, k$, interpreted as maintaining world 'real' resource use. In addition, we need data on the elasticity of substitution for each goods' class, σ_k, and on the CES share parameters for each country-commodity combination, β_i^k. Data on the elasticity of

[31] Alternatively, FTA effects on producers can be measured by the changes in the outward multilateral resistances. The OMRs capture the incidence of trade costs on producers and, by construction, are very similar to the factory-gate price indexes. We discuss OMR effects in the Appendix.

substitution are from Broda et al (2006),[32] and we choose to construct the CES share parameters using system (31) evaluated at the initial units choice:

$$\frac{q_i^k}{\sum_i q_i^k} = \sum_j \frac{(\beta_i^k t_{ij}^k)^{1-\sigma_k}}{\sum_i (\beta_i^k t_{ij}^k)^{1-\sigma_k}} \frac{\sum_k q_j^k}{\sum_{j,k} q_j^k}, \forall i, k. \tag{32}$$

With the β_i^k's and σ_k's at hand, we solve (31) to obtain factory-gate prices for each country-commodity-year combination in our sample. By construction, all p^*'s for 1990 are equal to one, because this is the year (without any FTAs) that we use for our normalization. The numbers for each of the other three years in our sample (1994, 1998 and 2002) take into account the presence and phasing-in of all free trade agreements that entered into force between 1990 and 2002. We use sectoral output shares as weights to obtain country-level estimates of the factory-gate prices. The numbers in columns 1-3 of Table 5 are percentage changes calculated from the difference between the national indexes for each of the three years with FTAs and the initial factory gate prices (with no FTAs). These percentage changes measure FTA incidence on the producers in each country.

Our indexes suggest very wide variability in the FTA effects on producers. In fact, we find that almost half of the producers in the world suffer globalization losses, while the other half enjoys gains from globalization. This suggests that the gains for the winners might be at the expense of the producers who suffer from globalization. We find further evidence for this when we present the ToT indexes. Without any exception, the five biggest losers are the regions that did not enter any FTAs during the 90's. However producer losses are relatively small. ROW and China register the largest losses of almost 0.5%, followed by Japan, S. Korea and Australia with similar losses. Trade diversion is a natural candidate to explain these results: better international market access for FTA

[32] Please see the Data Appendix for description and further details on these numbers. In principle, both the σ_k's and the β_i^k's can be estimated from the structural gravity model. The estimate of the elasticity of substitution arises as the coefficient on tariffs in the gravity model. Due to the lack of reliable sectoral tariff data for the period of investigation however, we choose to use the numbers from Broda et al (2006). The β_i^k's can also be constructed from gravity, each of them as combination of the exporters' fixed effects. We experimented with those estimates and we obtain initial factory-gate prices that are close to one but not exactly equal to one. Thus, for general equilibrium consistency we chose the method described in the text.

members results in worse access for the outsiders. Even though, our sample of outsiders is small, it is tempting to note that producers in the bigger outside regions suffer more.

Interestingly, the next two countries where producers suffer most from globalization are US and Canada. We attribute these effects to NAFTA, even though both countries entered other FTAs during the period of investigation as well. Producers in other developed nations suffered minor losses too. Overall, these findings are expected as there is clear trend in shifting manufacturing production from the developed to the developing world. It will be interesting to estimate similar effects in the services sector. The losses for the developed countries are across all sectors but are more pronounced in sectors such as Textile, Apparel, and Leather Products (Textile) and Basic Metal Industries (Metals).

The biggest winners from the intense integration during the 90s are producers from relatively small European and Latin American economies that signed FTAs with large trading partners. From the European economies, Poland and Hungary are leaders with producer gains of more than 7%, followed by Bulgaria with more than 5% increase in producer prices and Romania with 4.5%. CEFTA, EFTA and, consequently, EU membership should explain the strong positive effects in these nations. The large gains for these countries come at the expense of other EU members. This is supported by the small losses for the producers in the larger European economies.

Of the Latin American countries, Mexican producers are the biggest winners with more than 7% increase in their factory-gate prices. Series of bilateral FTAs as well as agreements between Mexico and most of the other Latin American economies are candidates to explain this result. However, it is most likely that the North American Free Trade Agreement (NAFTA) is the main reason for the gains in Mexico.[33] Combined with the fact that US and Canada are among the countries with FTA producer losses, this result suggests that NAFTA has benefitted Mexican producers disproportionately, at the expense of producers in the other two partners.

Overall, our estimates of the FTA incidence on producers suggests that smaller FTA members enjoy very large gains at the expense of relatively small losses for the producers

[33] In the next section, we investigate and decompose the importance of different FTAs in the case of Mexico.

in their larger FTA partners.

FTA Effects on Buyers. Once we have obtained the factory-gate prices, we use system (12) to calculate the inward multilateral resistances for each country-commodity combination and each year in our sample and to estimate FTA incidence on buyers. FTA effects on buyers in the world are reported in columns 4-6 of Table 5. Country-level indexes are obtained by aggregating the country-commodity numbers with sectoral-level expenditure shares used as weights. The numbers in each column are percentage changes between the inward multilateral resistances for the corresponding year, which by construction take into account FTA effects, and the IMRs from column 1, which are constructed as if there were no any free trade agreements. Column '%Δ02' captures the total effects over the period 1990-2002 because the 2002 bilateral trade costs (used in the construction of the 2002 IMRs) account for the cumulative, direct FTA impact.

Overall, we find that, without any exception, buyers in the world have benefitted from the intense integration during the 90's and that the benefits have increased over time. It is important to note that even buyers in nations that did not enter any free trade agreement during the period of investigation enjoy lower prices.[34] As can be seen from the table, all five such regions in our sample (Australia, China, Japan, South Korea and ROW) register small IMR decreases. Another example is Morocco. This country did not enter any FTAs until 2000, yet it enjoyed small IMR falls in 1994 and even small IMR increase in 1998. The gains increased significantly in 2002 after Morocco signed an FTA with the European Union in 2000. We explain the gains for buyers who stayed out of globalization with spill-over effects: producers in nations that entered FTAs enjoy gains that are passed over to all their trading partners, including the ones with whom they have no FTAs.

The variability of the FTA effects on buyers across countries is wide and the pattern makes good intuitive sense for the most part. One would expect the biggest FTA winners

[34] By definition, the IMR values in principle are comparable to price indexes, and in particular their variation across countries might be expected to reflect variation in consumer (or user) price indexes across regions. The IMR's have more variation than CPI's, and we expect that they only loosely track variations in consumer price indexes. A possible explanation is that the inward incidence of trade costs probably falls on intermediate goods users in a way that does not show up in measured prices. In addition, by construction, the IMRs capture the home bias in preferences that cannot show up in prices.

to be relatively small countries that have been heavily involved in globalization over the period of investigation. Thus, it should not be surprising to find that the largest FTA gains are for some small European economies including Hungary, Poland and Bulgaria. A possible explanation for the effects on these nations is that all of them are founding members of the Central European Free Trade Agreement (CEFTA) in 1993, and, more importantly, that each of them signed an agreement with, first, the European Free Trade Association (EFTA), and then, with the European Union (EU). Romania follows a similar integration pattern and also registers significant buyer gains.

Buyers in many of the Latin American countries are in the upper tail of the FTA gains' distribution too. Mexico and Bolivia are leaders with consumer gains of 6.8% and 5.5%, respectively, followed by Uruguay, Chile, Ecuador and Argentina. All these nations are members of the Latin American Free Trade Agreement (LAFTA), since 1993. In addition, most of these countries are (founding) members of Mercosur and have FTAs with each other. Finally, NAFTA and series of bilateral FTAs between Mexico and other countries may contribute to the positive effects for this particular country.[35] Another country that enjoys large buyer gains is Tunisia. The explanation is this nation's FTA with the EU in 1998. Note that in 1994, Tunisia only experience very small gains from the integration taking place in the rest of the world.

Buyers in most of the developed economies enjoy moderate FTA gains. This is in accordance with the classical trade theory prediction of smaller gains from freer trade for the larger trading partners. Finally, we find that buyers in the five regions that were not involved in any trade agreement initiated between 1990 and 2002 are among the regions that enjoy the smallest gains from globalization taking place in the rest of the world. However, more importantly, they enjoy some gains too.

Terms of Trade Indexes. We combine buyer and seller indexes for each country and year in our sample to obtain terms of trade (ToT) numbers and their percentage changes

[35]When interpreting our results, the reader should remember that the equilibrium welfare effects in each country are generated in response to the impact of all FTAs in our sample. While it is probably true that the strongest FTA effect on Mexico comes from NAFTA, the model allows for any other FTA to also influence the welfare of Mexican consumers and producers, even if Mexico is not part of the FTA at all. This is why we observe welfare effects for the countries that did not participate in any free trade agreement initiated between 1990 and 2002.

due to FTAs as:

$$\%\Delta ToT_i = \%\Delta p_i^* - \%\Delta P_i, \forall i \tag{33}$$

These indexes are reported in the last three columns of Table 5. Several properties stand out. First, the only regions whose terms of trade worsen during the the 90's are the ones that did not enter any FTA during this period. This implies that, even though buyers in these regions enjoyed small FTA gains, integration in the rest of the world has stronger, negative impact on the sellers as their losses outweigh buyers' gains. Second, all countries that entered FTAs during the 90's enjoy real income (ToT) gains. This suggests that (i) the direct FTA effects among trading partners dominate the indirect FTA impact from ongoing globalization in the rest of the world, and (ii) the losses for the producers in larger FTA members are dominated by consumer gains at the national level. Both of these findings are in support of the classical trade theory predictions for overall FTA gains, even in the presence of producer losses.

Third, the four nations with largest ToT improvement during the 90s (of more than 10%) include Poland, Hungary, Mexico, and Bulgaria. Tunisia is close to follow with ToT improvement of more than 9%. As noted earlier, the explanation is that all of these nations are small and each of them engaged in intensive integration with considerably larger partners. Notably, both buyers and sellers in these economies experience significant gains from globalization. Finally, as expected, large nations benefit less from FTAs. Thus, almost all developed economies are ordered in the lower tail of the distribution of ToT increases. However, it is important to emphasize that all FTA members enjoy some gains. For example, even though US and Canadian producers suffered globalization losses (probably due to NAFTA) the net effect on these economies is welfare improvement. In sum, our findings suggest that integration benefits FTA members but hurts outsiders.

Global Efficiency Measures. To calculate global efficiency indexes (first at the commodity level and then at the world level), first, we obtain aggregates of the outward multilateral resistances (presented and described in the Appendix) and of the inward multilateral resistances (described above) across all countries. Then, as described in the theoretical section, we construct efficiency measures for each year in our sample. Percentage changes are obtained from the difference between the efficiency numbers constructed as if there were no FTAs (the 1990 indexes), and the corresponding indexes that account for FTAs and their phasing-in effects in each of the other three years, 1994, 1998 and 2002. Efficiency estimates are reported in Table 6. The first eight rows of the table report global sectoral indexes and the last row presents the global efficiency measure for world manufacturing in each year. The last column of the table presents the total efficiency changes caused by FTAs during the whole period of investigation.

As can be seen from column '%Δ2002', without any exception, all of the sectors in our sample enjoy efficiency gains and there is wide variability across industries. The largest effect is for Textiles, where we estimate an efficiency gain due to FTAs of almost 2 percent. Metals and Machinery also register large gains of close to 1 percent. Food is close to follow with 0.7 percent. The sectors with smallest efficiency gains are Paper, Minerals, Chemicals and Wood. Our findings suggest that natural resource sectors gained less from free trade. A possible explanation is that, on average, these industries are subject to lower trade protection as compared to, for example, Machinery and Textiles. In addition, we would expect much lower trade diversion effects in resource sectors. It is also worth noting that decomposition of the efficiency numbers reveals that most efficiency gains are on the buyers' side.

The sectoral level efficiency measures combine to a global efficiency index for the world of almost 0.8, which is driven by the large combined share of Food, Textiles, Metals and Machinery in world manufacturing. It is also interesting to note without any exception, for each sector as well as for global manufacturing, we see that the FTA numbers presented in Table 6 increase over time. In sum, the indexes presented here reveal large efficiency gains due to the FTAs that entered into force between 1990 and 2002. In addition, we provide evidence that the global efficiency FTA effects are persistent over time.

2.5 Counterfactual Experiments

The framework of this paper is now applied to isolate the effects of a particular free trade agreement (NAFTA) as well as the impact of all FTAs signed by a specific nation (Mexico).[36] The choice of NAFTA and Mexico, respectively, for counterfactual experiments seems natural as both have been objects of interest for an extensive literature.[37]

First, we estimate a hypothetical set of multilateral resistances, factory-gate prices and corresponding FTA ToT effects as if there is no NAFTA (but all other FTAs are still in place). Then, we shut down the rest of the Mexican free trade agreements and we estimate the effects from globalization happening elsewhere in the world.

Table 7 presents our findings. For brevity, we only report the changes in the total welfare (ToT) effects.[38] The numbers in Columns 1 of the table are the indexes from the last column of Table 5, capturing total welfare effects from all FTAs that entered into force during the period of investigation. Column 2 reports welfare effects without NAFTA. The estimates are revealing. First, we find that NAFTA benefits all members, but most of all Mexico. We estimate a staggering fall in the ToT gains for Mexico. NAFTA accounts for more than 80% percent of the gains from all Mexican FTAs, equivalent to more than 11% gains in real income.[39] Canada and the US benefit from NAFTA too, but the real income gains for these countries are significantly smaller, about 0.1% for each country. These results are in accordance with findings from series of sophisticated and computationally intensive CGE models.[40] Second, our estimates indicate that without NAFTA both Canada and US will actually suffer from integration taking place in the rest of the world during the period of investigation. Note, for example, that the welfare effect

[36]These FTAs include LAFTA/LAIA (1993) and series of bilateral agreements between Mexico and other partners including Bolivia (1995), Costa Rica (1995), Columbia (1995) (As part of the Group of Three. The third country, Venezuela, is not in the sample), the EU (2000), and Israel (2000).

[37]Our framework can be applied to study series of other interesting counterfactual experiments including global free trade, switch on FTAs for all bilaterals $i \neq j$, or a 1% fall in trade barriers for all bilaterals $i \neq j$. Another area where our methods can lead to potentially very important contributions is in providing much needed empirical evidence on whether regionalism is a stumbling block or a stepping stone toward global free trade. See the concluding section for more interesting applications.

[38]Separate indexes for the effects on consumers and producers, yearly numbers, and indexes at the country-commodity level are available by request.

[39]Our estimate of the welfare gains for Mexico falls in the upper portion of the distribution of estimates obtained in most prior models. Usually the gains for Mexico are estimated at 5%-6% , but our estimate of 11% real gains from NAFTA over the period 1994-2002 is remarkably close to the prediction for 11% welfare gains by the year 2000 from McLeery (1992), and a bit lower than the prediction of 14% increase in Mexico's GDP by 2003 from Klein and Salvatore (1995). McCleery (1992) accounts for the dynamic gains from the endogenous productivity growth caused by increase in the volume of trade. Klein and Salvatore (1995) rely on the Wharton Econometric Forecasting Associates (WEFA) econometric models described in Klein (1991).

[40]See Brown et al. (1992a) for a concise summary of the findings from leading CGE models regarding the welfare implications of NAFTA.

for Canada becomes negative after the removal of NAFTA, even though this country has bilateral FTAs with Chile and Bolivia. This suggests that (i) either the direct effects of these two FTA's on Canadian producers are negative and outweigh consumer gains, or (ii) that the effects of globalization elsewhere dominate the direct Canada-Chile and Canada-Bolivia FTA effects.

Third, the hypothetical removal of NAFTA has moderate impact on other countries too.[41] Even though small, the welfare effects on the rest of the world make good intuitive sense. According to our estimates, the majority of developed economies and countries where producers do not compete directly with Mexican producers will suffer mild losses if NAFTA were not there. Spill-over effects on consumers explain these results. On the other hand, many small, labor-intensive economies from our sample experience welfare gains from the removal of NAFTA. The natural explanation is trade diversion toward the large US market, which no longer is served 'freely' by Mexico and Canada. As a simple test for this argument, we correlate the potential gains for these countries and the relative volume of their exports to US. The correlation coefficient is positive. Similar results are obtained at the product level.

In the next experiment we shut down all FTAs in which Mexico took part during the period of investigation. The resulting changes in the national terms of trade indexes are reported in column 3 of Table 7. Several properties stand out: (a) Mexico is the country that suffers the largest welfare loss. The total FTA welfare effects for this country become negative. If not involved in integration, this country would have suffered a minor (0.1%) decrease in its terms of trade and manufacturing real GDP due to the FTAs happening elsewhere in the world. (b) All other Latin American countries also experience welfare losses due to the removal of the FTA relations that they have with Mexico.[42] Most of the Latin American countries, however, still enjoy positive FTA welfare effects, probably due to the strong FTA connections among themselves. Costa Rica is the only exception with negative terms of trade changes. (c) Some (more developed) economies in Europe

[41]The small effects on the rest of the world are in accordance with the conclusions from Brown et al. (1992b).

[42]Note that some of those countries would have benefitted from the removal of NAFTA. Probably due to trade diversion.

also suffer mild welfare losses. This implies that the direct effects of the removal of the FTA between Mexico and the European Union dominate the indirect (trade diversion) effects from the removal of the rest of the Mexican FTAs (but NAFTA).

Overall, the results from this section provide evidence in support of the plausibility of our FTA indexes. In addition, the counterfactual experiments demonstrate that the simple general equilibrium framework that we develop produces reasonable results and generates useful insights.

3 Conclusion

The numbers presented in this paper portray a regional integration process in the 1990's that increased efficiency each manufacturing sector and in the global economy overall, provided many integrating partners with substantial gains and inflicted small losses on a few countries that did not enter FTA's. The methods developed and the numbers calculated here should be useful for many other purposes.

Our results include a multi-dimensional (country, commodity, and time) data set of producer price, terms of trade and global efficiency indexes that can be used to test numerous predictions from the theoretical literature on trade liberalization. Preliminary investigation indicates that larger FTA gains are associated with larger number of FTA partners and larger increase in the volume of trade caused by FTAs. In addition, FTA real income gains are inversely related to relative country size and to pre-FTA volumes of trade. These relationships accord with stylized theoretical trade predictions, and open avenues for future empirical work. Importantly, our indexes can be used to provide much needed empirical evidence on whether regionalism is a stumbling block or a stepping stone toward global free trade.

The paper offers new methods for analyzing the international externality effects of many policy changes other than FTA's or other trade policies. In a global economy all policies affect the terms of trade. Future work on domestic policy changes that affect internal trade costs relative to international ones (such as China's massive infrastructure investments), affect supplier costs and volume or buyer costs and volume (such as carbon emissions controls) can readily be examined within this framework. Analysis of intra-national vs. inter-national policies yields important insights (see for example Anderson and Yotov, 2010a).

The simplicity, tractability, and predictive power of the structural gravity model make it an attractive complement to Computable General Equilibrium (CGE) simulation models. The general equilibrium structure of distribution naturally nests inside typical CGE structures, pointing the way toward a better combination of empirical and simulation modeling.

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Table 1: Summary Statistics

Commodity	1992					2002					σ	Std.D.
	Exports		Output		# of	Exports		Output		# of		
Description	Mean	Std. D.	Mean	Std. D.	Zeros	Mean	Std. D.	Mean	Std. D.	Zeros		
Food	1.1e+09	1.4e+10	5.9e+10	1.4e+11	133	1.5e+09	1.9e+10	2.7e+16	1.6e+17	61	5.66	0.94
Textiles	5.0e+08	5.3e+09	2.6e+10	6.6e+10	123	5.5e+08	5.2e+09	2.8e+15	1.7e+16	45	4.93	0.99
Wood	2.3e+08	2.9e+09	1.1e+10	2.1e+10	290	3.6e+08	4.8e+09	4.5e+11	2.6e+12	139	4.83	1.08
Paper	5.7e+08	8.5e+09	2.4e+10	5.2e+10	255	7.4e+08	1.2e+10	8.4e+14	5.1e+15	148	5.13	1.23
Chemicals	1.5e+09	1.8e+10	6.4e+10	1.3e+11	124	2.3e+09	2.7e+10	5.7e+15	3.5e+16	43	5.08	1.00
Minerals	2.6e+08	3.1e+09	1.3e+10	2.8e+10	236	3.9e+08	4.6e+09	2.2e+15	1.3e+16	131	5.46	1.52
Metals	5.3e+08	6.0e+09	2.4e+10	4.9e+10	261	5.5e+08	6.7e+09	3.6e+10	1.2e+11	153	5.38	0.96
Machinery	3.1e+09	3.8e+10	1.3e+11	2.7e+11	97	4.3e+09	4.7e+10	2.9e+15	1.7e+16	22	5.89	0.99
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

Notes: This table reports descriptive statistics for the key estimation variables for the first and the last years in our sample. Summary statistics for the rest of the variables are available by request. The total number of observations for each commodity in each year is always 1681 (41*41). Bilateral export values and output are measured in 1000s of US dollars dollars. The elasticity values are aggregated, as described in the text.

Table 2: Free Trade Agreements

European Union, or EU (1958): Belgium–Luxembourg, France, Italy, Germany, Netherlands, Denmark (1973), Ireland (1973), United Kingdom (1973), Greece (1981), Portugal (1986), Spain (1986), Iceland (1994) Austria (1995), Finland (1995), Sweden (1995)
European Free Trade Association, or EFTA (1960): Austria (until 1995), Denmark (until 1973), Iceland (1970), Finland (1986–1995), Norway, Portugal (until 1986), Sweden (until 1995), Switzerland, United Kingdom (until 1973)
Latin American Free Trade Agreement/Latin American Integration Agreement, or LAFTA/LAIA (1993–): Argentina, Bolivia, Brazil, Chile, Ecuador, Mexico, Uruguay
EU–EFTA Agreement/European Economic Area (1973/1994)
US–Israel (1985)
US–Canada (1989)
EFTA–Israel (1993)
Central Europe Free Trade Agreement, or CEFTA (1993): Hungary, Poland, Romania (1997), Bulgaria (1998)
EFTA–Turkey (1992)
EFTA–Bulgaria (1993)
EFTA–Hungary (1993)
EFTA–Poland (1993)
EFTA–Romania (1993)
Andean Community (1993): Bolivia, Columbia, Ecuador
EU–Hungary (1994)
EU–Poland (1994)
North American Free Trade Agreement, or NAFTA (1994): Canada, Mexico, United States
Bolivia–Mexico (1995)
Costa Rica–Mexico (1995)
EU–Bulgaria (1995)
EU–Romania (1995)
Columbia–Mexico (1995). As part of the Group of Three. The third country, Venezuela, is not in the sample.
Mercosur (1991): Argentina, Brazil, Uruguay (formed in 1991 FTA in 1995)
Mercosur–Chile (1996)
Mercosur–Bolivia (1996)
EU–Turkey (1996)
Canada–Chile (1997)
Canada–Israel (1997)
Hungary–Turkey (1998)
Hungary–Israel (1998)
Israel–Turkey (1998)
Romania–Turkey (1998)
Poland–Israel (1998)
EU–Tunisia (1998)
Mexico–Chile (1999)
EU–Israel Agreement (2000)
EU–Mexico (2000)
EU–Morocco (2000)
EFTA–Morocco (2000)
Poland–Turkey (2000)
Mexico–Israel (2000)
Chile–Costa Rica (2002)

This table lists, in chronological order, all free trade agreements used in the estimations. Only agreements involving the countries in our sample are included. FTAs that entered into force before 1990 are used, when appropriate, to construct the lagged variables of the FTA dummy variable. The latter is constructed from FTAs that entered into force after 1990.

Table 3: Phased-in Effects of Free Trade Agreements

	(1) Food	(2) Textile	(3) Wood	(4) Paper	(5) Chemicals	(6) Minerals	(7) Metals	(8) Machinery
FTA	0.397	0.587	-0.131	-0.084	0.119	0.019	0.322	0.298
	(0.063)**	(0.069)**	(0.104)	(0.040)*	(0.032)**	(0.054)	(0.042)**	(0.062)**
L.FTA	0.219	0.399	0.130	0.066	0.165	0.274	0.215	0.361
	(0.049)**	(0.069)**	(0.100)	(0.048)	(0.039)**	(0.057)**	(0.048)**	(0.060)**
L2.FTA	0.076	0.305	0.287	0.325	0.212	0.194	0.389	0.301
	(0.057)	(0.088)**	(0.082)**	(0.074)**	(0.060)**	(0.059)**	(0.057)**	(0.101)**
CONST	16.730	15.887	13.795	15.083	16.867	14.577	14.941	16.096
	(0.016)**	(0.036)**	(0.050)**	(0.035)**	(0.021)**	(0.009)**	(0.013)**	(0.145)**
FTA_TOTAL	0.693	1.291	0.286	0.306	0.496	0.487	0.927	0.960
	(0.087)**	(0.100)**	(0.114)*	(0.069)**	(0.064)**	(0.068)**	(0.060)**	(0.122)**
N	6724	6724	6724	6724	6724	6724	6724	6724
LL	-4.314e+07	-6.873e+07	-1.496e+07	-1.734e+07	-9.668e+07	-1.051e+07	-6.312e+07	-3.072e+08

Huber-Eicker-White robust standard errors are reported in parentheses. + $p < 0.10$, * $p < .05$, ** $p < .01$. Each PPML estimation is performed with bilateral dummies and directional (source and destination) time-varying fixed effects. Fixed effects estimates are omitted for brevity. Total FTA effects are calculated as the sum of the individual FTA estimates for each product. Standard errors for the total effects are obtained with the delta method. L.FTA and L2.FTA are the first and the second four-year lags, respectively.

Table 4: PPML Gravity Estimates

	(1) Food	(2) Textile	(3) Wood	(4) Paper	(5) Chemicals	(6) Minerals	(7) Metals	(8) Machinery
DIST	-1.134	-1.306	-1.246	-1.247	-0.961	-1.185	-1.038	-0.797
	(0.039)**	(0.068)**	(0.050)**	(0.035)**	(0.030)**	(0.043)**	(0.045)**	(0.035)**
BRDR	0.541	-0.076	0.617	0.383	0.313	0.687	0.573	0.419
	(0.085)**	(0.121)	(0.094)**	(0.062)**	(0.064)**	(0.076)**	(0.074)**	(0.071)**
LANG	0.019	0.230	-0.105	0.435	0.313	-0.077	0.308	0.116
	(0.086)	(0.132)+	(0.081)	(0.057)**	(0.076)**	(0.071)	(0.073)**	(0.072)
CLNY	0.306	-0.060	0.205	0.009	0.154	0.341	0.242	-0.070
	(0.105)**	(0.132)	(0.089)*	(0.078)	(0.082)+	(0.070)**	(0.073)**	(0.078)
SMCTRY	3.259	1.378	2.789	2.886	2.576	3.208	2.210	1.949
	(0.091)**	(0.151)**	(0.118)**	(0.077)**	(0.066)**	(0.098)**	(0.094)**	(0.081)**
FTA	-0.599	0.035	0.313	-0.021	-0.312	-0.403	-0.244	0.373
	(0.065)**	(0.111)	(0.083)**	(0.056)	(0.057)**	(0.079)**	(0.064)**	(0.108)**
CONST	20.562	22.450	18.681	19.930	20.156	18.716	18.835	18.445
	(0.337)**	(0.658)**	(0.477)**	(0.323)**	(0.316)**	(0.378)**	(0.564)**	(0.844)**
N	6724	6724	6724	6724	6724	6724	6724	6724
ll	-2.939e+08	-4.300e+08	-8.022e+07	-9.504e+07	-5.634e+08	-5.408e+07	-2.813e+08	-1.557e+09

Huber-Eicker-White robust standard errors are reported in parentheses. + $p < 0.10$, * $p < .05$, ** $p < .01$. Each PPML estimation is performed with directional (source and destination) time-varying fixed effects. Fixed effects estimates are omitted for brevity. The years used in the panel are 1990,1994,1998, and 2002.

Table 5: General Equilibrium FTA Effects, 1990-2002

Country Name	Factory-gate Prices			IMR's			ToT Effects		
	%Δ94	%Δ98	%Δ02	%Δ94	%Δ98	%Δ02	%Δ94	%Δ98	%Δ02
Argentina	0.44	0.83	1.11	-0.45	-1.06	-1.97	0.89	1.89	3.09
Australia	-0.05	-0.17	-0.34	-0.03	-0.12	-0.24	-0.02	-0.05	-0.10
Austria	0.02	1.49	3.48	-0.31	-2.07	-4.06	0.33	3.56	7.54
Bulgaria	0.86	3.16	5.43	-0.65	-2.37	-4.86	1.51	5.53	10.29
Blgm-Lxmbrg	-0.05	-0.07	-0.08	-0.06	-0.24	-0.45	0.01	0.17	0.37
Bolivia	0.50	1.17	2.01	-1.97	-3.76	-5.66	2.47	4.92	7.67
Brazil	-0.01	-0.02	0.00	-0.20	-0.40	-0.61	0.18	0.38	0.61
Canada	-0.02	-0.11	-0.23	-0.04	-0.16	-0.29	0.02	0.05	0.06
Switzerland	-0.03	-0.10	-0.18	-0.18	-0.32	-0.45	0.15	0.22	0.27
Chile	0.25	0.79	1.60	-1.10	-2.20	-3.26	1.34	2.98	4.86
China	-0.07	-0.24	-0.45	-0.03	-0.11	-0.22	-0.04	-0.13	-0.23
Columbia	-0.05	-0.05	-0.10	-0.02	-0.10	-0.23	-0.02	0.05	0.13
Costa Rica	-0.04	0.00	-0.01	0.03	-0.03	-0.19	-0.07	0.03	0.18
Germany	-0.05	-0.05	-0.04	-0.10	-0.37	-0.64	0.05	0.31	0.61
Denmark	-0.02	0.22	0.44	-0.08	-0.41	-0.81	0.06	0.62	1.25
Ecuador	0.22	0.55	0.98	-1.04	-2.05	-3.18	1.27	2.60	4.15
Spain	-0.04	-0.02	0.00	-0.04	-0.20	-0.40	0.01	0.17	0.41
Finland	-0.02	0.33	1.15	-0.31	-1.79	-3.38	0.30	2.11	4.53
France	-0.05	-0.07	-0.09	-0.06	-0.23	-0.44	0.01	0.16	0.34
UK	-0.04	-0.07	-0.09	-0.06	-0.24	-0.44	0.02	0.17	0.35
Greece	-0.03	0.43	0.86	-0.01	-0.21	-0.57	-0.01	0.64	1.43
Hungary	2.51	4.84	7.23	-1.77	-4.04	-6.74	4.28	8.87	13.98
Ireland	-0.02	0.08	0.18	-0.05	-0.26	-0.54	0.03	0.34	0.72
Iceland	0.05	0.02	0.00	-0.21	-0.41	-0.65	0.26	0.43	0.65
Israel	0.35	0.53	1.57	-0.14	-0.36	-1.04	0.49	0.89	2.61
Italy	-0.06	-0.06	-0.05	-0.07	-0.29	-0.54	0.00	0.22	0.49
Japan	-0.06	-0.23	-0.44	-0.03	-0.13	-0.26	-0.03	-0.10	-0.18
S. Korea	-0.06	-0.22	-0.43	-0.02	-0.11	-0.22	-0.04	-0.11	-0.20
Morocco	-0.07	-0.27	1.49	-0.00	-0.00	-2.02	-0.07	-0.27	3.51
Mexico	2.11	4.40	7.14	-1.38	-3.47	-6.64	3.48	7.86	13.78
Netherlands	-0.03	0.01	0.06	-0.06	-0.27	-0.51	0.03	0.28	0.57
Norway	0.03	-0.03	-0.05	-0.26	-0.48	-0.65	0.30	0.45	0.59
Poland	2.61	5.06	7.80	-1.88	-4.32	-7.22	4.49	9.38	15.02
Portugal	-0.06	-0.06	-0.02	-0.05	-0.20	-0.42	-0.01	0.15	0.40
Romania	0.65	2.67	4.69	-0.41	-1.77	-3.86	1.06	4.44	8.55
ROW	-0.07	-0.25	-0.45	-0.03	-0.11	-0.20	-0.04	-0.14	-0.25
Sweden	0.01	0.59	1.73	-0.32	-2.15	-4.00	0.33	2.74	5.73
Tunisia	-0.10	2.54	5.14	0.00	-1.88	-4.26	-0.10	4.43	9.40
Turkey	0.49	2.17	3.92	-0.27	-1.38	-3.11	0.76	3.56	7.03
Uruguay	1.23	2.43	3.56	-1.28	-2.75	-4.62	2.51	5.18	8.18
USA	-0.02	-0.11	-0.24	-0.05	-0.16	-0.29	0.03	0.05	0.05

Notes: This table reports percentage changes in the factory-gate prices, the inward multilateral resistances and the ToT indexes for each country and year in our sample. Country-level factory-gate prices are constructed as weighted averages across all country-commodity indexes with output shares used as weights. IMR's are aggregated from the country-commodity numbers with expenditure shares used as weights. ToT's are calculated as the difference between the corresponding effects on producers (the factory-gate prices) and consumers (IMR's).

Table 6: Global Efficiency Indexes, 1990-2002

Country Name	%Δ1994	%Δ1998	%Δ2002
Food	0.201	0.496	0.707
Textile	0.365	1.127	1.825
Wood	0.002	0.108	0.448
Paper	0.001	0.005	0.127
Chemicals	0.059	0.206	0.431
Minerals	0.000	0.110	0.321
Metals	0.225	0.551	0.989
Machinery	0.111	0.413	0.788
Mnfctrng	0.124	0.393	0.716

Notes: This table reports global efficiency measures for each sector and aggregate manufacturing numbers obtained from the country-commodity OMR's, as described in the text.

Table 7: Counterfactual FTA Experiments

Country Name	All FTAs	No NAFTA	No FTAs Mexico
Argentina	3.09	3.13	2.95
Australia	-0.10	-0.07	-0.07
Austria	7.54	7.51	7.51
Bulgaria	10.29	10.22	10.21
Blgm-Lxmbrg	0.37	0.37	0.37
Bolivia	7.67	7.73	7.42
Brazil	0.61	0.66	0.54
Canada	0.06	-0.05	-0.04
Switzerland	0.27	0.28	0.28
Chile	4.86	4.91	4.67
China	-0.23	-0.20	-0.19
Columbia	0.13	0.26	0.01
Costa Rica	0.18	0.38	-0.04
Germany	0.61	0.61	0.61
Denmark	1.25	1.25	1.24
Ecuador	4.15	4.30	3.86
Spain	0.41	0.42	0.41
Finland	4.53	4.53	4.52
France	0.34	0.35	0.34
UK	0.35	0.35	0.35
Greece	1.43	1.44	1.43
Hungary	13.98	13.84	13.84
Ireland	0.72	0.73	0.71
Iceland	0.65	0.68	0.65
Israel	2.61	2.60	2.59
Italy	0.49	0.51	0.50
Japan	-0.18	-0.16	-0.15
S. Korea	-0.20	-0.17	-0.17
Morocco	3.51	3.51	3.50
Mexico	13.78	2.34	-0.11
Netherlands	0.57	0.57	0.57
Norway	0.59	0.61	0.60
Poland	15.02	14.87	14.87
Portugal	0.40	0.43	0.41
Romania	8.55	8.48	8.47
ROW	-0.25	-0.23	-0.22
Sweden	5.73	5.72	5.71
Tunisia	9.40	9.26	9.25
Turkey	7.03	6.96	6.95
Uruguay	8.18	8.19	7.95
USA	0.05	-0.07	-0.06

Notes: The indexes in this table are aggregate country-level ToT effects. The numbers in column 1 account for the presence of all FTAs. The numbers in column 2 are constructed as if there was no NAFTA. The indexes in the third column are calculated as if Mexico was not involved in any FTA during the 90s.

Appendix

Data

In this project, we use industry-level data on bilateral trade flows and output, and we construct expenditures for each trading partner and each commodity class, all measured in thousands of current US dollars for the corresponding year. In addition, we use data on bilateral distances, contiguous borders, colonial ties, common language, elasticity of substitution, and the presence of regional free trade agreements.

Bilateral trade flows are defined as the value of exports from partner i to partner j. We use the CEPII *Trade, Production and Bilateral Protection Database*[43] (TradeProd) as the main trade data source because it implements a consistent procedure for mapping the CIF (cost, insurance and freight) values reported by the importing countries in COMTRADE to the FOB (free on board) values reported by the exporters in COMTRADE.[44] This increases the number of non-missing observations in the sample.[45] To further increase the number of non-missing trade flows, we add export values from the United Nation Statistical Division (UNSD) Commodity Trade Statistics Database (COMTRADE).[46] Internal commodity-level trade for each country is constructed as the difference between total output and aggregate exports to all trading partners, which come from the same data sources. As can be seen from columns (5) and (10) of Table 1, the number of zero trade flows in the sample is small. It varies from 97 to 290 (less than 20%) in 1990 and is even smaller in 2002. This suggests that the consequences of throwing information away by using the standard log-linear OLS estimator should not be severe. Nonetheless, the PPML estimator is still preferable because, in addition to accounting for the zero trade

[43] For details regarding this database see Mayer, Paillacar and Zignago (2008).

[44] The TradeProd database is based on the CEPII *Base pour l'Analyse du Commerce International* (BACI) data. For details regarding BACI see Gaulier and Zignago (2008).

[45] As noted in Anderson and Yotov (2009), in principle, gravity theory calls for valuation of exports at delivered prices. In practice, valuation of exports FOB avoids measurement error arising from poor quality transport cost data.

[46] We access COMTRADE through the World Integrated Trade Solution (WITS) software, http://wits.worldbank.org/witsweb/. The software reports trade data in three different concordances including Harmonized System (HS) Revisions 1989/92 and 1996, and the Standard International Trade Classification (SITC), which are automatically converted to ISIC Rev. 2. To obtain maximum number of observations, we combine the data from the different concordances.

flows, it also controls for heteroscedasticity.

Industrial output level data comes from two sources. The primary source is the United Nations' UNIDO Industrial Statistics database, which reports industry-level output data at the 3-digit and 4-digit level of ISIC Code (Revisions 2 and 3). We use the CEPII TradeProd database[47] as a secondary source of product-level output data. Since completeness of the output shares data is crucial for the calculation of the factory-gate prices and the multilateral resistance indexes, we interpolate some of the missing output values for the sample countries, which account for 15.6% of the observations, and extrapolate, using each country's GDP deflator index, an additional 5.1% of the data. GDP deflator indexes are from the World Bank's World Development Indicators (WDI) Database. GDP deflator data were available for all countries and all years in the sample.[48]

In order to be able to calculate the multilateral resistance indexes, we also need data on the elasticities of substitution at the commodity level. These data are from Broda et al (2006) who estimate and report 3-digit HS indexes for 73 countries for the period 1994-2003, which almost coincides with the period of investigation in this study. we obtain the values reported in column (11) of Table 1 by aggregating the original country-level indexes to the 2-digit ISIC level of commodity aggregation using the value of imports as weights. In addition, since some of the original indexes seem implausible,[49] Following Anderson and Yotov (2010), we bound them in the interval [4,12] before aggregation. As can be seen from Table 1, the elasticity numbers seem plausible and are relatively homogeneous across commodities (which should not be surprising given the high level of aggregation) as well as across countries for a given commodity.[50]

To construct distance, we employ the distance measure from Mayer and Zignago

[47]TradeProd uses the OECD STAN Industrial Database in addition to UNIDO's Industrial Statistics Database.

[48]GDP deflators for ROW are calculated as weighted averages across all countries included in this aggregate region. Output shares are used as weights.

[49]For example the elasticity estimate for the 3-digit HS commodity category 680, which includes Articles of asphalt, Panels,boards,tiles,blocks, Friction materials etc. is 195.95 while the estimate for category 853 including Electrical capacitors, Electrical resistors, Electric sound/visual signalling equipment etc. is 1.07.

[50]Three countries (Bulgaria, Belgium-Luxembourg, and Israel) from our sample were not present in the nations covered by Broda et al (2006). We proxied for the elasticities of those countries using the elasticity of substitution for ROW, which is constructed as a weighted average across all countries composing it.

(2006), which is appealing because the same procedure can be used to calculate bilateral distances as well as internal distances. In addition, we use it to consistently estimate the distances between any country in my sample and the rest of the world (ROW), as well as the internal ROW distance. Mayer and Zignago's (2006) procedure (based on Head and Mayer (2000)[51]) uses the following formula to generate weighted distances: $d_{ij} = \sum_{k \in i} \frac{pop_k}{pop_i} \sum_{l \in j} \frac{pop_l}{pop_j} d_{kl}$, where pop_k is the population of agglomeration k in trading partner i, and pop_l is the population of agglomeration l in trading partner j, and d_{kl} is the distance between agglomeration k and agglomeration l, measured in kilometers, and calculated by the Great Circle Distance Formula. To calculate distances, we use data on latitude, longitude, and population for the 50 biggest cities in each country in my sample and for the 100 biggest cities in the rest of the world.[52] Finally, data on the other standard gravity variables, such as common language, common border, and colonial ties are from CEPII's *Distances* Database and from Rose (2004).

Outward Multilateral Resistances

We obtain the outward multilateral resistances for each country-commodity combination and each year in our sample from system (4):[53]

$$(\beta_i^k p_i^{*k} \Pi_i^k)^{1-\sigma_k} = Y_i^k / Y^k. \tag{34}$$

It is easy to see that (34) satisfies (16). We use the country-commodity OMR indexes and the aggregation procedure described in the text to construct the global efficiency measures from Table (6).

Here, we aggregate the country-commodity OMR's to the country-level. These numbers, reported in Table 8, measure FTA incidence on producers. Without going into details, we note two properties of the country-level OMR changes: (i) There is wide vari-

[51]Head and Mayer (2000) provide an excellent summary and discussion of the alternative approaches of distance calculations.

[52]All data on latitude, longitude, and population is from the World Gazetteer web page at http://world-gazetteer.com/.

[53]Alternatively, the OMRs can be calculated from (14). By construction, both procedures obtain identical results.

ability in the OMRs. The pattern of variation is inversely related to the variation of the factory-gate prices. This should not be surprising given the theoretical relation between these two numbers. (ii) In terms of magnitude, the trade cost incidence on producers is similar to the change the factory-gate prices that they face. Interestingly, the OMR changes are a bit smaller than the corresponding p^* changes.

Table 8: FTA Effects on OMRs, 1990-2002

Country Name	%Δ1994	%Δ1998	%Δ2002
Argentina	-0.442	-0.825	-1.095
Australia	0.046	0.170	0.339
Austria	-0.021	-1.459	-3.318
Bulgaria	-0.868	-3.049	-5.082
Blgm-Lxmbrg	0.053	0.074	0.084
Bolivia	-0.530	-1.195	-2.010
Brazil	0.022	0.042	0.035
Canada	0.023	0.107	0.231
Switzerland	0.025	0.098	0.178
Chile	-0.246	-0.771	-1.545
China	0.068	0.240	0.450
Columbia	0.052	0.060	0.115
Costa Rica	0.042	0.011	0.025
Germany	0.047	0.053	0.030
Denmark	0.018	-0.210	-0.427
Ecuador	-0.226	-0.544	-0.955
Spain	0.037	0.027	0.005
Finland	0.018	-0.316	-1.100
France	0.045	0.075	0.095
UK	0.038	0.069	0.093
Greece	0.030	-0.445	-0.869
Hungary	-2.411	-4.518	-6.584
Ireland	0.024	-0.071	-0.172
Iceland	-0.055	-0.013	-0.002
Israel	-0.355	-0.523	-1.535
Italy	0.062	0.064	0.052
Japan	0.056	0.226	0.443
S. Korea	0.059	0.225	0.427
Morocco	0.073	0.271	-1.461
Mexico	-2.028	-4.121	-6.454
Netherlands	0.035	-0.004	-0.054
Norway	-0.029	0.036	0.055
Poland	-2.536	-4.780	-7.135
Portugal	0.062	0.062	0.030
Romania	-0.644	-2.556	-4.370
ROW	0.071	0.247	0.455
Sweden	-0.007	-0.575	-1.663
Tunisia	0.107	-2.438	-4.756
Turkey	-0.481	-2.078	-3.661
Uruguay	-1.254	-2.421	-3.470
USA	0.025	0.109	0.238

Notes: This table reports percentage changes in the outward multilateral resistances for each country. Country-level OMR's are constructed as weighted averages across all country-commodity indexes with output shares used as weights.