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Abstract

This paper finds that the estimates of Armington elasticities (the elasticity of substitution between groups of products identified by country of origin) obtained from multilateral trade data can differ from those obtained from bilateral trade data. In particular, the former tends to be higher than the latter when trade consists largely of intermediate inputs. Given that the variety of intermediate inputs traded across borders is increasing rapidly, and that the effect of this increase is not adequately captured in multilateral trade data, the evidence shows that the use of multilateral trade data to estimate Armington elasticities needs caution.

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I. Introduction

Neoclassical trade models have long assumed that goods are homogeneous irrespective of where they are produced. What does this mean empirically? The composite commodity theorem (Leontief, 1936) asserts that a group of commodities can be treated as a single good, if their prices move in parallel.[2] In data, however, prices of goods produced in different countries do not typically move together. This behavior was first pointed out by Armington (1969). Ever since, it has become a standard practice among empirical trade researchers to treat goods produced in different countries differently and to assume a constant elasticity of substitution among them.[3] Such an elasticity–for example, the elasticity of substitution between the basket of U.S. goods and that of French goods–is referred to as an Armington elasticity.

The Armington specification has played a crucial role in deriving some of the important findings in the recent empirical literature. First, Armington elasticities, as estimated by Shiells, Stern, and Deardorff (1986), Gallaway, McDaniel, and Rivera (2003), and many others, have played an important role in the welfare analysis of (as well as trade patterns predicted by) the computable general-equilibrium (CGE) models such as the Michigan Model of World Production and Trade and the Global Trade Analysis Project models. For example, McDaniel and Balistreri (2002) recently demonstrated the sensitivity of general-equilibrium models to Armington elasticities. They illustrated that unilateral trade liberalization would be harmful to Colombia with low Armington elasticities (between 1 and 3) but would be beneficial with high Armington elasticities (around 5).

Second, the gravity model has become the empirical workhorse of international trade. Most theoretical and empirical specifications of the gravity model, such as Bergstrand (1985), assume an Armington structure emphasizing imperfect product substitutability by country of origin. The implication and findings based on the gravity models are also sensitive to Armington elasticity estimates. For example, Baier and Bergstrand (2001) showed that about a third of the growth of world trade between the late 1950s and the late 1980s could be explained by reductions in tariff rates and transport costs. The contribution of these reductions in explaining the growth of world trade crucially depends on their estimate of the Armington elasticity (which was 6.4).

Third, a long-standing question in the international trade literature is the puzzlingly high U.S. income elasticity of demand for imports. Feenstra (1994) constructed a price index that took new product varieties into consideration to solve this puzzle. This key price index, *the exact price index*, is sensitive to the estimates of Armington elasticities. If the Armington elasticity approaches infinity, the conventional price index and Feenstra's exact price index are no different, but if it approaches unity, two are significantly different. Feenstra's estimates, ranging between 2.96 and 8.38 among manufactured goods, show that the variety adjustment plays an important role in explaining the high U.S. income elasticity puzzle.

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[2]For more details see Deaton and Muellbauer (1980).

[3]An alternative product differentiation model in the literature is the increasing-returns model (Krugman, 1980). This model identifies varieties by individual firm instead of by individual country as in the Armington model. Head and Ries (2001), however, find empirical evidence that favors differentiated products of the Armington type rather than of the Krugman type.

Despite its role in the literature, however, alternative versions of Armington specifications are commonly used in the international trade literature without explicit tests for their validity. This paper focuses on two versions that are directly associated with the choice of trade data used in empirical studies, namely, that between multilateral and bilateral trade data.[4]

One version, seen in most studies mentioned above including Armington (1969), assumes that the basket of goods identified by country is *weakly separable*, meaning that the marginal rate of substitution between two goods from the same basket (or the same country) is separable from the rest.[5] For example, the marginal rate of substitution between two goods from the basket of domestic goods does not depend on foreign goods.

The second version, the one used in Bergstrand (1985) and Feenstra (1994), assumes that the basket of goods identified by country is *strongly separable*, meaning that the marginal rate of substitution between two goods (not only from the same country, but also from two different countries) is separable from the rest. For example, the marginal rate of substitution between the U.S. and French products (for example, California wine and Bordeaux wine) does not depend on German products (for example, Rhine wine).

The first version is more restrictive, because the marginal rate of substitution between two goods from any combination of two different countries is assumed inseparable from each other in the first version but not in the second. It is this restriction that allows us to assume that the elasticity estimates obtained from multilateral trade data are the same as those obtained from bilateral trade data.

To use Armington elasticities estimated from bilateral and multilateral trade data interchangeably, we need to examine whether these elasticities are indeed the same. Alternatively, we need to examine whether the more restrictive (weak separability) assumption is indeed valid. To answer this question, we estimate two types of elasticities for each industry. One is the elasticity of substitution between the basket of domestic goods and that of imports as a whole (for example, the U.S. food products versus foreign food products); we call this elasticity (estimated from multilateral trade data) the *intergroup elasticity*. The other is the elasticity of substitution between the basket of imports from one foreign country and that from another (for example, French food products versus German food products); we call this elasticity (estimated from bilateral trade data) the *intragroup elasticity*.

Evidence from this analysis, which uses industry-level data at the two-digit International Standard Industrial Classification (ISIC) level from 14 industrial countries between 1970 and 1990, indicates that the elasticity estimates obtained from multilateral trade data are in most cases different from those obtained from bilateral trade data. In addition, the results suggest that the relationship between the inter- and intragroup elasticities is not uniform across industries. To make this comparison across industries, we make the following distinction: industries predominantly producing intermediate inputs are referred to as *intermediate inputs* industries, and industries

[4]Many other versions of Armington specifications are discussed in the literature besides the two addressed in this paper. For example, Kohli (1998) and Shiells, Roland-Holst, and Reinert (1993) explore more flexible functional forms than the ones discussed here.

[5]See Pollak and Wales (1992) for definitions of *weak separability* and *strong separability.*

predominantly producing final goods are referred to as *final goods* industries. We find that, in the intermediate inputs industries, the intergroup elasticity (estimated using multilateral trade data) tends to be higher than the intragroup elasticity (estimated using bilateral trade data), but no such evidence is found in the final goods industries. This result reveals that a potential problem (in *not* making the multilateral versus bilateral distinction) is more serious in the intermediate inputs sector.

Finally, we argue that some unique evidence observed in the intermediate inputs sector may be attributed to an upward bias in the intergroup elasticity (estimated from multilateral trade data) due to the growth of outsourcing and associated changes in the composition of trade that are not captured in multilateral trade data. This argument is based on the so-called *variety bias* of Feenstra (1994).

II. Analytical Framework

This section discusses the specification of preferences, which determines imports of consumption goods, and then of technology, which determines imports of intermediate inputs.

A. Preferences

Functional Forms We assume that multiple groups of goods identified by country (within each sector) are *strongly separable*. The functional form used here to describe such preferences is the two-level constant elasticity of substitution (CES) functional form introduced by Sato (1967).[6] The empirically useful property of this functional form is that, together with the assumption of two-stage budgeting, where the consumer can allocate total expenditure in two stages, the utility maximization problem can be effectively separated into two stages. More specifically, the utility-maximizing problem of a representative agent in country i for a given level of total demand for goods belonging to a specific industry Y_i is as follows:

$$\begin{aligned} \text{Max } U_i &= [\delta_i D_i^{\frac{\sigma_i-1}{\sigma_i}} + (1-\delta_i) M_i^{\frac{\sigma_i-1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i-1}}, \text{ where} && (1) \\ M_i &= [\sum_{j\neq i} \phi_{ij} M_{ij}^{\frac{\sigma_{si}-1}{\sigma_{si}}}]^{\frac{\sigma_{si}}{\sigma_{si}-1}} \\ \text{subject to } Y_i &= p_i^D D_i + p_i^M M_i, \text{ where} && (2) \\ p_i^M M_i &= \sum_{j\neq i} p_{ij}^M M_{ij}. \end{aligned}$$

Note that $\sigma_i, \sigma_{si} \in \{(0,1) \text{ and } (1,\infty)\}$, and $\delta_i, \phi_{ij}, D_i, M_i$, and M_{ij} all take positive values. U_i is the industry-level utility of the representative consumer in country i. D_i is the industry-specific demand for domestic goods. M_i is the industry-specific aggregate volume of imports. M_{ij} is the industry-specific volume of imports from a foreign country j. σ_i is country i's elasticity of substitution between domestic goods and aggregate imports (the *intergroup elasticity*), and σ_{si}

[6] In the 1960s Uzawa (1962), McFadden (1963), and Sato (1967) developed *n*-factor production functions that retained the CES properties of the two-factor case of Arrow and others (1961). Among the three, the two-level CES of Sato (1967) is the most general and has empirical applicability to this paper.

is country i's elasticity of substitution among imports from different countries (referred to as the *intragroup elasticity*).[7] δ_i and ϕ_{ij} are the industry-specific *distribution parameters*.[8] p_i^D is the free-on-board (f.o.b.) price of domestic goods in country i, p_{ij}^M is the price of imports from country j inclusive of the cost of insurance and freight (c.i.f.) and customs duties, and, finally, p_i^M is the price of aggregate imports in country i.

The functional form used in Armington (1969),

$$U_i = [\delta_i D_i^{\frac{\sigma_i - 1}{\sigma_i}} + \sum_{j \neq i} \delta_{ij} M_{ij}^{\frac{\sigma_i - 1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i - 1}}, \tag{3}$$

or the one more commonly used in many studies using multilateral trade data M_i,

$$U_i = [\delta_i D_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - \delta_i) M_i^{\frac{\sigma_i - 1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i - 1}}, \tag{4}$$

can be expressed as a special case of the two-level CES functional form described in equation (1). For example, under the assumption that multiple goods are only *weakly separable* ($\sigma_i = \sigma_{si}$), equations (3) and (4) can be derived from equation (1).[9] In other words, all three specifications (1), (3), and (4) are equivalent, and thus the distinction between multilateral and bilateral is not necessary, if weak separability is a valid assumption.

Optimality Conditions The following optimality conditions, obtained from the utility maximization problem described above, are the bases for our regression equations:[10]

$$\frac{M_i}{D_i} = (\frac{p_i^M}{p_i^D})^{-\sigma_i} (\frac{1 - \delta_i}{\delta_i})^{\sigma_i} \tag{5}$$

$$\frac{M_{ij}}{M_{ik}} = (\frac{p_{ij}^M}{p_{ik}^M})^{-\sigma_{si}} (\frac{\phi_{ij}}{\phi_{ik}})^{\sigma_{si}}. \tag{6}$$

Equation (5) implies that, for each 1 percent increase in the relative price of the industry-specific aggregate imports with respect to the price of industry-specific domestic goods, there is a σ_i percent fall in the ratio of the industry-specific aggregate volume of imports to country i's industry-specific gross output. A similar interpretation applies to equation (6).

B. Production Technology

Let us turn to the case where the products traded are intermediate inputs. We assume analogously that the technology that the representative producer faces in its cost minimization problem has the following property: inputs from different countries are *strongly separable* within

[7] The terms *intergroup* and *intragroup elasticities* are taken from Sato (1967).

[8] The term *distribution parameter* is taken from Arrow and others (1961). In the trade literature, δ_i is sometimes referred to as the *home bias* parameter.

[9] There are additional assumptions besides $\sigma_i = \sigma_{si}$: we need $\delta_{ij} = (1 - \delta_i)\phi_{ij}$ to obtain equation (3) and $M_i = [\sum_{j \neq i} \phi_{ij} M_{ij}^{\frac{\sigma_i - 1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i - 1}}$ to obtain equation (4).

[10] Using these optimality conditions to estimate elasticities implies that we focus on the substitution effect; the income elasticities of demand for M_i, M_{ij} and D_i are assumed to be 1. We may, however, be treating some of the income effect imbedded in data as part of the substitution effect; see Marquez (2001) for a survey of different income elasticity estimates in the literature.

each sector (see Appendix I for the cost minimization problem). Under such a specification, the first-order conditions of the cost minimization problem provide the same optimality conditions as equations (5) and (6), where D_i now represents domestic inputs and M_i and M_{ij} represent imported inputs.

In the empirical part of this paper, elasticities are estimated from the same regression equations based on equations (5) and (6). The elasticities σ_i and σ_{si} estimated for the intermediate inputs sectors are, however, the *elasticity of technical substitution* in production rather than the *elasticity of substitution* in consumption.[11]

C. Special Features in Intermediate Inputs Trade

The international trade literature refers to the growth of intermediate inputs trade in many different ways: for example, as an increase in *vertical specialization of production* (Hummels, Ishii, and Yi, 2001; Yi, 2003), as an increase in *forward and backward linkages* between firms across countries (Krugman and Venables, 1995), as an increase in the *fragmentation* of production processes across borders (Jones, 2000; Arndt and Kierzkowski, 2001), as an increase in *outsourcing* (Feenstra, 1998; Feenstra and Hanson, 2001), as the *thinner slicing of the value chain* (Krugman, 1995), and so on. These papers, despite the differences in terminologies used, have made and analyzed the same observation that the volume as well as the *variety* of intermediate inputs traded across countries has increased over time.[12]

What is the implication of these new varieties of intermediate inputs on the estimation of the elasticity of technical substitution? Feenstra (1994) shows that *new varieties* of imports can be thought of as having prices that fall from infinity (where the cross-border demand is zero) to the actual level (where the cross-border demand becomes positive). In other words, ignoring the entry of new varieties can undermine the actual fall in prices.

By ignoring new varieties in the estimation of Armington elasticities, therefore, we may be asking a smaller-than-actual fall in *relative* prices (for example, a smaller-than-actual fall in $\frac{p_i^M}{p_i^D}$ or $\frac{p_{ij}^M}{p_{ik}^M}$) to explain the observed increase in the *relative* demand for inputs (for example, an increase in $\frac{M_i}{D_i}$ or $\frac{M_{ij}}{M_{ik}}$), and thus the elasticity estimates may be biased upward. Assuming that the rate at which new varieties are entering the international markets is similar across countries, such a bias is more likely in the intergroup elasticity estimates (obtained from multilateral trade data) than in the intragroup elasticity estimates (obtained from bilateral trade data).

For example, consider a simple scenario where the United States and France used to export only large engines for aircraft and Germany only medium-size engines for automobiles, but now all three countries export both types of engines.[13] In this scenario, changes in the price of the

[11]Section III.D discusses how we classify the two-digit ISIC industries into final (consumption) goods and intermediate inputs industries.

[12]Explanations for the growth of intermediate inputs trade, however, differ among these papers: some attribute it to a fall in transport costs (Krugman and Venables, 1995), others to a fall in tariff rates (Yi, 2003), others to a fall in information costs (Jones, 2000), and so on.

[13]This scenario does not necessarily imply that the United States and France never used to produce

basket of German engines relative to that of the basket of French engines (changes in $\frac{p_{ij}^M}{p_{ik}^M}$) would be unaffected by the variety change as long as both the German and the French baskets have added the same number of new varieties each. On the other hand, changes in the price of the basket of foreign inputs relative to that of domestic inputs (changes in $\frac{p_i^M}{p_i^D}$) would be affected by the variety change, since the basket of foreign inputs has relatively more new varieties (for example, two new engines in the foreign basket versus one new engine in the domestic basket). Thus an upward bias in the elasticity estimates is more likely if multilateral trade data are used instead of bilateral trade data.

The variety explanation may not be a sufficient explanation, since the use of the variety-adjusted price index in Feenstra (1994) does not eliminate the intergroup versus intragroup differences.[14] Nevertheless, an increase in the variety in the basket of foreign goods *relative* to that of domestic goods is a likely explanation for the evidence found in the intermediate inputs sector.[15]

III. Empirical Specifications

A. Decomposition of Prices

The key data in both of our regression equations are price data, in particular, import price data. Import price data (typically constructed by dividing the value of imports by the volume of imports) are not widely available and can be very sensitive to the quality of the volume data.

The use of import price data, therefore, tends to limit the variation in the sample–either the cross-sectoral variation, the cross-country variation, or both. For example, Feenstra (1994) covers a wide cross-country variation by using U.S. bilateral trade data, but the number of products he considers is limited. All other studies using U.S. multilateral trade data, such as Blonigen and Wilson (1999), Gallaway, McDaniel, and Rivera (2003), and Shiells, Stern, and Deardorff (1986), have wider cross-sectoral coverage, but small cross-country variations. One exception is the recent contribution by Erkel-Rousse and Mirza (2002). They use unit value indices that they have constructed from bilateral trade data from the French statistical institute INSEE. Their data have both large cross-sectional and cross-country variations, but access to these data is limited.

Many recent studies (such as Baier and Bergstrand, 2001; Head and Ries, 2001; Hummels, 1999) have turned away from price data to tariff and transport cost data to estimate Armington elasticities. These studies, however, ignore the effect of changes in productivity on prices.

Assumptions To cover a wide range of bilateral trade relations and to allow prices to reflect the cost of production in each country, we make two assumptions about the domestic price, p_i^D,

medium-size engines, or that Germany never used to produce large engines. Instead, it implies that the prices of these products in these countries used to be sufficiently high that cross-border demand was zero.

[14]The estimates obtained in the first and the second stages in Feenstra (1994) are assumed equivalent to the intragroup and the intergroup elasticities, respectively.

[15]Further research is needed to establish this claim.

import prices, p_{ij}^M, and the price of the import aggregate, p_i^M. First, we assume that industries are *perfectly competitive*. This assumption is consistent with the specification that Head and Ries (2001) use for the Armington model, which is a constant-returns-to-scale model with varieties differentiated by nationality, in contrast to an increasing-returns model where varieties are linked to firms. Second, we make the standard *Samuelson iceberg* assumption for transport costs (Hummels, 1999; Baier and Bergstrand, 2001; and many others). The idea is that, for each unit of goods shipped from another region, only a fraction arrives, and this melting effect is captured in import prices.

Domestic Price The assumption of perfect competition allows us to let unit total costs equal prices. Unfortunately, comparable total cost data across countries and across sectors are not available. At best, the producer price indices are available, but these indices are not comparable at *levels*. As a second-best solution, we let domestic prices, p_i^D, be a log-linear function of the unit labor cost, c_i:[16]

$$\ln p_i^D = \gamma_{0i} + \gamma_{1i} \ln c_i. \tag{7}$$

The markup, γ_{1i}, is the price elasticity with respect to unit labor costs in country i. Under perfect competition this markup should equal the labor cost share.[17]

Import Price With Samuelson's iceberg assumption, the import price can be described as $p_{ij}^M = (1 + tar_{ij})(1 + tran_{ij}) p_j^D$, where p_j^D is the f.o.b. price of a good produced in country j, tar_{ij} is the tariff rate imposed on imports from country j, and $trans_{ij}$ is the transport cost (cost of insurance and freight) for shipping goods from country j. For simplicity, we let $\tau_{ij} = (1 + tar_{ij})(1 + tran_{ij})$, and therefore the import price is expressed as follows:

$$\ln p_{ij}^M = \gamma_{0i} + \gamma_{1i} \ln c_j + \ln \tau_{ij}, \tag{8}$$

where c_j is the industry-specific unit labor cost in country j.[18]

Price of the Import Aggregate Finally, the price of the import aggregate, p_i^M for all i, is assumed to take the Laspeyres price index form

$$\ln p_i^M = \gamma_{0i} + \gamma_{1i} \sum_{j \neq i} \omega_j \ln c_j + \sum_{j \neq i} \omega_j \ln \tau_{ij}, \tag{9}$$

[16]The proximity of the producer price index of the United Nations' *Industrial Statistical Yearbook* and the unit labor cost of the OECD's *International Sectoral Data Base* is within the acceptable range; the correlation coefficients between the *percentage change* in the producer price index and the unit labor cost for the Group of Seven countries are 0.85 (in the machinery and equipment industry) and 0.84 (in the "other manufacturing products" industry) at the higher end, and 0.66 (in the food products industry) and 0.69 (in the nonmetallic minerals products industry) at the lower end.

[17]Shephard's lemma states that the cost-minimizing labor input is given by the derivative of the cost function with respect to the wage rate and hence implies that $\frac{\partial p_{it}}{\partial c_{it}} = 1$, where c_{it} is the unit labor cost and p_{it} is the unit total cost. Since $\gamma_{1it} = \frac{\partial \ln p_{it}}{\partial \ln c_{it}} = \frac{\partial p_{it}/p_{it}}{\partial c_{it}/c_{it}} = 1 \cdot \frac{c_{it}}{p_{it}}$, γ_{1it} should equal $\frac{c_{it}}{p_{it}}$, which is the labor cost share.

[18]The markup γ_{1i} is indexed by the importer i rather than the exporter j, since the markup may be adjusted according to which markets the goods are sold in.

where the weight (ω_j) is the share of imports from country j, $\omega_j = \frac{M_{ij}p_{ij}^M}{\sum_{j\neq i} M_{ij}p_{ij}^M}$.[19]

B. Regression Equations

Two regression equations are derived from the optimality conditions in equations (5) and (6). Taking the natural logarithm of both sides of equations (5) and (6) and adding time subscripts in appropriate places yields the following equations:

$$\ln \frac{M_{it}}{D_{it}} = -\sigma_i \ln \frac{p_{it}^M}{p_{it}^D} + \sigma_i \ln \frac{1-\delta_i}{\delta_i} \tag{10}$$

$$\ln \frac{M_{ijt}}{M_{ikt}} = -\sigma_{si} \ln \frac{p_{ijt}^M}{p_{ikt}^M} + \sigma_{si} \ln \frac{\phi_{ij}}{\phi_{ik}}. \tag{11}$$

By substituting prices, as specified in equations (7), (8), and (9), the relative prices in the right-hand side of equations (10) and (11) take the form

$$\ln \frac{p_{it}^M}{p_{it}^D} = \gamma_{1i} \sum_{j\neq i} \omega_{jt} \ln \frac{c_{jt}}{c_{it}} + \sum_{j\neq i} \omega_j \ln \tau_{ij} \tag{12}$$

$$\ln \frac{p_{ijt}^M}{p_{ikt}^M} = \gamma_{1i} \ln \frac{c_{jt}}{c_{kt}} + \ln \frac{\tau_{ij}}{\tau_{ik}}. \tag{13}$$

By substituting equations (12) and (13) into equations (10) and (11), two regression equations are derived:[20]

$$\ln \frac{M_{it}}{D_{it}} = -\sigma_i \gamma_{1i} \sum_{j\neq i} \omega_{jt} \ln \frac{c_{jt}}{c_{it}} + \sigma_i \ln \frac{1-\delta_i}{\delta_i} - \sigma_i \sum_{j\neq i} \omega_j \ln \tau_{ij} + u_{it} \tag{14}$$

$$\ln \frac{M_{ijt}}{M_{ikt}} = -\sigma_{si} \gamma_{1i} \ln \frac{c_{jt}}{c_{kt}} + \sigma_{si} \ln \frac{\phi_{ij}}{\phi_{ik}} - \sigma_{si} \ln \frac{\tau_{ij}}{\tau_{ik}} + v_{ijkt}, \tag{15}$$

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[19] An alternative import price index can be derived using duality:

$$p_i^M = \left(\sum_{j\neq i} \phi_{ij}^{\sigma_{si}} p_{ij}^{M(1-\sigma_{si})} \right)^{\frac{1}{1-\sigma_{si}}},$$

but this price index cannot be computed since it requires distribution parameters such as ϕ_{ij}, which cannot be separately identified from other time-invariant parameters such as τ_{ij} (see more details in the next subsection). Equation (9), which defines the price of aggregate imports as a variant of the geometric mean, is used as a second-best approximation to this price index, which defines it as a variant of the harmonic mean.

Other alternative price indices such as the log-change price index of Sato (1974) or the exact price index of Feenstra (1994) would not be applicable either, since they are expressed in terms of changes rather than levels.

[20] The left-hand side of the equation is in quantities rather than in values. Since trade data are given in values, appropriate price adjustments are made for the actual regressions (details are available from the author upon request).

where u_{it} and v_{ijkt} are disturbance terms. The reduced forms of these equations are

$$\ln \frac{M_{it}}{D_{it}} = \beta_{10} + \beta_{11i} \sum_{j \neq i} \omega_{jt} \ln \frac{c_{jt}}{c_{it}} + \beta_{12i} + u_{it} \tag{16}$$

$$\ln \frac{M_{ijt}}{M_{ikt}} = \beta_{20} + \beta_{21i} \ln \frac{c_{jt}}{c_{kt}} + \beta_{22ijk} + v_{ijkt}. \tag{17}$$

Notice that the second term (home bias) and the third term (transport costs and customs duties) on the right-hand side of equations (14) and (15) are jointly captured by the time-invariant unobserved fixed effects β_{12i} and β_{22ijk} in equations (16) and (17), respectively. β_{12i} is a fixed effect specific to each importing country i, and β_{22ijk} is a fixed effect specific to each combination of trading partners (j and k) for each importing country i. Notice also that the slope parameters β_{11i} and β_{21i} in these equations are not a priori assumed to be the same across countries. That is, the inter- and intragroup elasticities (σ_i and σ_{si}) are not a priori assumed to be the same across countries.

There are two points to note on the empirical specifications described above. First, the time invariance of transport costs and tariff rates is a strong assumption.[21] To relax this assumption, time dummies are included in regression equation (16), which assumes that the reduction in transport costs and tariff rates is common across the industrial countries. If this assumption is valid, then the time-specific reductions in τ_{ij} and τ_{ik} in equation (15) should cancel out. Time dummies are therefore not included in regression equation (17).

Second, the markup (γ_{1i}) is set to equal the labor cost share, which results from the perfect competition assumption. Identifying the size of the markup (γ_{1i}) is critical in obtaining the structural parameters (σ_i and σ_{si}) from the reduced-form parameters (β_{11i} and β_{21i}). It is, however, possible that the markup (γ_{1i}) is higher than what we propose (possibly because of the presence of market power); in that case the true elasticities would be lower than the estimated ones.[22] Such a bias, however, would be present in both the intergroup and the intragroup elasticities and hence is not likely to invalidate the main findings of this paper.

C. Choice of Estimators

Random effects, fixed effects, and first differencing are still the most popular approaches to estimating unobservable effects in panel data models under *strict* exogeneity of the explanatory variables.[23] Even in the case of endogenous explanatory variables (as in the case of our model), it is common to use a transformation to eliminate the unobserved effect and then to select appropriate instruments in order to apply the instrumental variable (IV) estimator. For example,

[21] In fact, a common practice is to use the variation in tariff rates and transport costs over time to estimate elasticities of substitution (Baier and Bergstrand, 2001; Head and Ries, 2001; Hummels, 1999; and others).

[22] Indeed, Hall (1988), Basu (1996), and others find evidence for increasing returns and price-cost markups.

[23] Each of these is efficient under a particular set of assumptions. For example, the fixed effect estimator is more efficient if u_{it} is serially uncorrelated, whereas the first differencing estimator is more efficient if u_{it} follows a random walk. See Chapter 10 in Wooldridge (2002) for more details.

Erkel-Rousse and Mirza (2002) apply a family of IV estimators after removing the mean in the time dimension.

The estimates obtained from the IV estimator, however, can be sensitive to the choice of instrumental variables, as correctly pointed out by Erkel-Rousse and Mirza (2002). Moreover, and more important, removing the mean to eliminate the unobserved effect does not rule out serial correlation in the disturbance terms (in our regression equations, u_{it} and v_{ijkt}). It is well known that conventional panel techniques based on the generalized method of moments (GMM) break down and produce very large biases when the data exhibit unit root behavior.[24] Since our data contain unit roots, an alternative method is needed.

One alternative method is to use the GMM estimator with a proper treatment of time series (as in Feenstra, 1994). However, applying the family of GMM estimators in this paper is problematic in two dimensions. First, a rich cross-sectional variation, which is necessary to apply the GMM estimator, is available in estimating equation (17) but not in estimating equation (16). Second, the GMM estimators implicitly assume that the short-run dynamics are homogeneous across individual members of the panel. Although the short-run dynamics are not explicitly discussed in this paper, the assumption of homogeneity of the serial correlation dynamics is likely to be violated in aggregate trade data of this type.

An alternative solution to take care of unobservables, endogeneity, and serial correlation (with possible heterogeneity in the short-run dynamics) is to use the panel version of the Phillips and Hansen (1990) procedure, the panel fully modified ordinary least squares (FMOLS) estimator (Pedroni, 2000). This method fully modifies the ordinary least squares estimates (and hence eliminates the potential problem caused by endogeneity as well as serial correlation) by transforming the disturbance term (u_{it} and v_{ijkt}) and subtracting off a parameter that can be constructed from the estimated nuisance parameters and a term from the original data; see Pedroni (2000) for more details. To apply this method, both the left-hand side and the right-hand side variables in equations (16) and (17) must be nonstationary, and there must be a cointegrating relationship between the two: that is, the disturbance terms (u_{it} and v_{ijkt}) must be stationary. The group mean unit root tests of Im, Pesaran, and Shin (1997) and the group mean cointegration tests of Pedroni (1999) confirm that our data satisfy these time series properties.[25] We therefore use the panel FMOLS estimator.

An additional important benefit of using the panel FMOLS estimator is that the inter- and the intragroup elasticities do not have to be a priori assumed to be the same across countries. The null hypothesis such as $H_0 : \sigma = \sigma_s$ without country subscript i could be more restrictive since it makes the a priori assumption that the elasticities are the same across countries. On the other hand, the null hypothesis using the group-mean panel FMOLS estimator is based on elasticities

[24]The GMM estimates in Erkel-Rousse and Mirza (2002), which range between -76.9 (wrong sign) and 29.37 at the three-digit ISIC, may be an indication of large off-diagonal entries in the weighting (variance-covariance) matrix caused by possible serial correlation.

[25]The group-mean tests are used since they have an advantage over the pooled tests; the autoregressive parameter under the alternative hypothesis is not required to be the same across all countries in the panel in the group-mean tests, but this is required in the pooled tests.

estimated for each i (or each ijk) and averaged together for the group mean:

$$H_0 : \bar{\sigma} = \bar{\sigma}_s, \tag{18}$$

where $\bar{\sigma} = \frac{1}{N}\sum_{i=1}^{N}\sigma_i$ (N is the number of i) and $\bar{\sigma}_s = \frac{1}{N_s}\sum_{i=1}^{N_s}\sigma_{si}$, ($N_s$ is the number of ijk). Our test results therefore do not rely on an a priori assumption under either the null or the alternative hypothesis.

The panel FMOLS approach does not estimate the intergroup and intragroup elasticities jointly as in the case of the maximum likelihood estimator used in Brown and Heien (1972).[26] Rather, we estimate the elasticities separately for two reasons. First, the panel FMOLS estimator, although it does not minimize the residuals jointly, is a useful consistent estimator for the reasons discussed above. Second, assuming the independence of disturbances of a demand system expressed in terms of ratios, as in equations (16) and (17), is not as implausible as making that assumption for a demand system expressed in terms of levels (as in the demand system in Brown and Heien, 1972).[27]

D. Data

Trade and Production Data This analysis uses the International Sectoral Data Base at the two-digit ISIC level (1970-90) for the production data of 14 industrial countries.[28] It also uses the International Trade by Commodities Statistics at the two-digit Standard International Trade Classification (SITC) level (1970-90) for the trade data for the same set of countries. Tables 1 and 2 show the concordance of these two data sets.

The two-digit ISIC data are highly aggregated and cover heterogeneous products. A much higher level of disaggregation would be desirable; however, as discussed in Section III.A, improving the level of disaggregation, especially of the production cost data, would come only at the cost of losing cross-sectoral variations.

Input-Output Data This study also uses the OECD Input-Output Database, which can aid the analysis in two ways. First, it allows us to obtain industry-level domestic demand D_{it}, which is defined as $D_{it} = X_{it} - \sum_{j \neq i} E_{ijt}$, where X_{it} is industry-level demand for gross output (or total output) of country i and E_{ij} is industry-level exports to foreign country j. More specifically, these data are used to obtain a proxy for industry-level gross output (X_{it}). The trade literature typically sets $X_{it} \approx V_{it}$, where V_{it} is industry-level value added, and therefore input-output data

[26]Pollak and Wales (1992) also argue that to estimate the parameters of the demand systems corresponding to each group in the first stage and of the demand systems of the CES aggregators in the second stage would impose an implausible stochastic structure that prevents disturbances associated with demand functions for goods in one group from affecting the demand for goods in other groups.

[27]Details are available from the author upon request.

[28]The 14 industrialized countries used in this study are Australia, Belgium-Luxembourg, Canada, Denmark, France, Finland, Federal Republic of Germany, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and the United States.

are not used.[29] This approximation, however, can grossly understate or overstate the actual value of industry-level gross output (X_{it}), because value added (a proxy for the *supply* of gross output) equals gross domestic product (a proxy for the *demand* for gross output) only at the aggregate level and not at the industry level.[30] This paper therefore sets $X_{it} \approx \frac{1}{v_{i,90}} V_{it}$, where $v_{i,90}$ is the industry-level ratio of value added to gross output for 1990.[31]

Second, the OECD Input-Output Database is used to empirically distinguish the final (consumption) goods and intermediate inputs industries at the two-digit ISIC level. More specifically, the shares of intermediate and final demand in gross output are computed for 10 OECD member countries in 1990 for each industry (see Table 3 for these shares). If, for more than half of the countries in the sample, more than two-thirds of demand for the output of a given industry is for use as intermediate inputs, we classify that industry as part of the *intermediate inputs* sector. *Final* (*consumption) goods* industries are classified in an analogous manner.

According to this rule, agricultural products, mining, paper products, chemical products, nonmetallic mineral products, and basic metals products are included in the intermediate inputs sector, and food products, textiles, and "other manufacturing products" are included in the final consumption goods sector.[32] The machinery and equipment industry is not categorized into either sector because intermediate demand (such as the demand for metal products) and final demand (such as demand for automobiles) are equally important in this industry.[33]

Size of Panel Data The intergroup elasticities for each country i are obtained from each country's time series data between 1970 and 1990. The intergroup elasticities for the OECD member countries as a whole are estimated from the panel of 14 OECD member countries. That is, the size of the panel (the number of i) is 14.

---

[29]This approximation assumes constancy of the ratio between gross output and value added, or nonsubstitutability between materials and factors of production.

[30]For example, the U.S. input-output table for 1998 shows that the value added for agriculture was approximately $105 billion, but the sum of consumption, investment, government spending, and net exports of agricultural products was only about $35 billion.

[31]$v_{i,90}$ for Belgium, Finland, Norway, and Sweden are not available in the OECD Input-Output Database, and therefore the ratio for Denmark is used instead.

[32]If we had used data for the textiles industry (ISIC code 32) disaggregated at the three-digit level in the OECD Input-Output Database, the classification of apparel (ISIC code 322) as a final goods industry and of textiles proper (ISIC code 321) as an intermediate inputs industry would have been more apparent. In this study, however, the textiles industry is treated as a final goods industry, despite the fact that this industry produces a large amount of intermediate inputs.

[33]When we refer to final goods, we typically mean consumption goods. In the machinery and equipment industry (ISIC code 38), however, final goods are not necessarily consumption goods: for example, automobiles (in ISIC code 384) and televisions (in ISIC code 383) are durables demanded by consumers, but other final goods, such as office computing machinery (in ISIC code 385), are fixed investment goods demanded by producers. The relatively large share of fixed investment goods in this industry is another reason for not categorizing it as either an intermediate input or a final consumption goods industry.

The intragroup elasticities for each country i are estimated from the panel of $\binom{13}{2}$ binomial combinations of each country's trading partners. That is, the size of the panel (the number of jk) is 78 for each country i. The intragroup elasticities for the OECD member countries as a whole are estimated from the panel of 78 trading partners of all 14 countries. That is, the size of the panel (the number of ijk) is $1,092$ ($= 78 \times 14$).[34]

IV. Empirical Results

A. Elasticity Estimates Obtained from Multilateral Trade Data

The group-mean FMOLS estimates for the intergroup elasticities are obtained using regression equation (16). The group mean elasticities for the two-digit ISIC industries, hereafter referred to as the elasticities for the OECD, are reported in Table 6; they range between 0.94 and 3.54.[35]

Interestingly, the intergroup elasticities (estimated using multilateral trade data) for the intermediate inputs industries tend to be higher than those for the consumption goods industries. For example, the lowest elasticity, 0.94, is obtained in the food products and the "other manufacturing products" industries, both of which are considered final goods industries. In contrast, the highest elasticity, 3.53, is obtained in agriculture, which is considered an intermediate inputs industry.[36]

These intergroup elasticities are in line with other studies using multilateral trade data. For example, Blonigen and Wilson (1999) find that the ratio of industry shipments for final consumption is negatively associated with the Armington elasticity. Also, the elasticity estimates in Shiells, Stern, and Deardorff (1986), if averaged over two-digit ISIC categories, range from 0.39 in the food products industry (excluding tobacco) and 2.00 in the "other manufacturing" industry to 5.66 in the chemical products industry. If the estimates at the four-digit Standard Industrial Classification (SIC) by Gallaway, McDaniel, and Rivera (2003) are averaged to the two-digit ISIC, the elasticities are 1.23 for the textiles industry and 2.11 for the chemical products industry.

Our finding that the elasticity estimates are higher for the intermediate inputs sector than for the consumption goods sector is, however, broadly speaking inconsistent with the intuition dating back to the 1920s (see, for example, Marshall, 1925 and Hicks, 1946).[37]

[34]For most industries, the panel is smaller because of missing data.

[35]Before implementing the FMOLS estimator, the time series properties of the left-hand and right-hand-side variables and the cointegrating relationship between the two are tested: see Table 4 for the t-bar statistics for the unit root tests and the group augmented Dickey-Fuller (ADF) statistics for the cointegration tests. Also, the intergroup and intragroup elasticity estimates for the individual countries are reported in Table 5.

[36]The nonmetallic mineral products industry is an exception, but without Canada (whose estimated elasticity takes the wrong sign, -5.43), the estimate is much closer to the estimates of other intermediate inputs industries.

[37]Both Marshall (1925; Book V, Chapter VI), who first introduced the concepts of composite

B. Elasticity Estimates Obtained from Bilateral Trade Data

Let us now turn to the intragroup elasticities σ_{si}, which are estimated using regression equation (17). The elasticity estimates for the 14 OECD member countries as a whole are reported in Table 6; they range between 0.24 and 1.39.[38]

The counterintuitive pattern observed in the intergroup elasticities is not observed in the intragroup elasticities. In fact, the elasticity estimates tend to be lower for industries predominantly producing intermediate inputs (for example, 0.67, 0.56, and 0.75 in industries producing paper products, nonmetallic mineral products, and basic metals products, respectively) and higher for industries predominantly producing consumption goods (for example, 1.49 and 1.22 in textiles and "other manufacturing products," respectively).[39]

These intragroup elasticities are in line with those of other studies using bilateral trade data. For example, the estimates obtained by Hummels (1999) show that the weighted average of elasticities among final (consumption) goods industries is 6.82 and that among intermediate inputs industries is 3.58. Feenstra (1994), another study that uses bilateral trade data, finds the same pattern: the estimates for two goods that belong to the textiles industry (athletic shoes and knit shirts) average to 6.03, whereas those of two goods belonging to the basic metals industry (steel bars and steel sheets) average to 3.90.[40]

C. Comparisons

Two main findings emerge from our comparison of intergroup and intragroup elasticities. First, we find that the intergroup elasticities (estimated from multilateral trade data) are different from the intragroup elasticities (estimated from bilateral trade data), and the differences are statistically significant in most industries. The last column in Table 6 shows the Wald test statistics for the null of $H_0 : \bar{\sigma} = \bar{\sigma}_s$. The weak separability assumption is rejected at the 95 percent level in all industries except for food products and nonmetallic mineral products.[41] The rejection of

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demand (or supply), and Hicks (1946; Chapters III and VII), who later made the mathematical refinement of Marshall's analysis by the use of concepts such as the marginal rate of substitution and the elasticity of substitution, consider that the demand for intermediate inputs of firms is governed by a choice among complementary sets of factors of production, whereas the consumer's budget tends to be a choice among mild substitutes.

[38] Again, before implementing the FMOLS estimator, we check the time series properties of the left-hand and right-hand-side variables and the cointegrating relationship between the two: see Table 4 for the t-bar statistics for the unit root tests and the group ADF statistics for the cointegration tests. The elasticity estimates for the individual countries are reported in Table 5.

[39] The food products industry is an exception, but without the United Kingdom (whose estimated elasticity takes the wrong sign, -2.11) the estimate becomes much closer to the estimates of other final (consumption) goods industries.

[40] It is commonly observed that the Armington elasticities estimated from time-series variation tend to be lower (and around unity) than those estimated off of cross-sectional variation. The literature still has not established why this is the case; further investigation is needed, but is beyond the scope of this paper.

[41] The Wald test statistics are also reported at the individual country level in Table 5.

the null highlights the importance of the intergroup versus intragroup distinction and thus the multilateral versus bilateral distinction in estimating Armington elasticities.

Second, the relationship between the elasticity estimates obtained from multilateral trade data and those estimated from bilateral trade data differs across sectors. Figure 1 illustrates the elasticities reported in Table 6; it plots the intergroup elasticities on the vertical axis and the intragroup elasticities on the horizontal axis. If the intergroup and intragroup elasticities are the same (under the weak separability assumption), all the points should lie along the 45-degree line. This is not the case. All the points representing intermediate inputs industries (and hence the elasticities of technical substitution in production) lie above the 45-degree line, indicating that the intergroup elasticities are higher than the intragroup elasticities. In contrast, all the points representing final (consumption) goods industries (and hence the elasticities of substitution in consumption) lie on or below the 45-degree line, indicating that the intragroup elasticities are equal to or higher than the intergroup elasticities.

V. Conclusion

The Armington specification, which differentiates products by country of origin, has played a key role in many areas of the international trade literature. It has been employed in the welfare analysis of computable general-equilibrium models, in the theoretical foundations of the gravity equation, and in solving the U.S. income elasticity puzzle. Despite its role in the literature, two versions of Armington specifications (one for studies using multilateral trade data, and the other for those using bilateral trade data) are used in the literature without explicit tests of their validity.

This paper finds that the Armington elasticities obtained from multilateral trade data tend to be higher than those obtained from bilateral trade data in the intermediate inputs sector. We argue that the growth of outsourcing and associated changes in the composition of intermediate inputs trade may not be captured in multilateral trade data and hence may result in a bias in the estimates obtained from these data. To fully understand why two alternative Armington specifications lead to different elasticity estimates, however, more research is needed.

The Cost Minimization Problem

The cost minimization problem of the representative agent in country i is as follows:

$$
\begin{aligned}
&Min \quad Cost_i = p_i^D D_i + p_i^M M_i \\
&where\ p_i^M M_i = \sum_{j \neq i} p_{ij}^M M_{ij} \\
&subject\ to\ \overline{X}_i = \left[\delta_i D_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - \delta_i) M_i^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}} \\
&where \quad M_i = \left[\sum_{j \neq i} \phi_{ij} M_{ij}^{\frac{\sigma_{si} - 1}{\sigma_{si}}} \right]^{\frac{\sigma_{si}}{\sigma_{si} - 1}}
\end{aligned}
\tag{19}
$$

where $\overline{X}_i$ is industry-specific aggregate inputs; D_i is industry-specific domestic inputs, computed in a similar manner as in the consumption good case; M_i is the industry-specific aggregate volume of imported inputs; M_{ij} is industry-specific imported inputs from foreign country j; σ_i is the elasticity of technical substitution between domestic inputs and the aggregate of imported inputs; σ_{si} is the elasticity of technical substitution among imported inputs from different countries; δ_i and ϕ_{ij} are the industry-specific distribution parameters; p_i^D is the f.o.b. price of domestic inputs in country i; p_i^M is the c.i.f. (plus customs duties) price of the aggregate of imported inputs in country i; and p_{ij}^M is country i's c.i.f. (plus customs duties) import price of inputs from country j.

The first-order conditions provide the optimality conditions, which are identical in functional form to equations (5) and (6).

Table 1. Concordance Between Industry Data (ISDB) and Trade Data (ITCS)

International Sectoral Data Base (ISDB) at the two-digit ISIC level			International Trade by Commodities Statistics (ITCS) at the two-digit SITC level	
1	Agriculture, hunting, forestry, and fishing (AGR)	11	Agriculture	00 Live animals chiefly for food
				01 Meat and meat preparations 1/
				02 Dairy products and birds' eggs 1/
				04 Cereals and cereal preparations 1/
				05 Vegetables and fruit 1/
				06 Sugar, sugar preparations, and honey 1/
				07 Coffee, tea, cocoa, spices, and manufactures thereof 1/
				29 Crude animal and vegetable materials, n.e.s.
		12	Forestry and lodging	
		13	Fishing	03 Fish, crustaceans, molluscs, and preparations thereof 1/
2	Mining and quarrying (MID)	21	Coal mining	32 Coal, coke, and briquettes
		22	Crude petroleum and natural gas production	33 Petroleum, petroleum products, and related materials
				34 Gas, natural and manufactured
		23	Metal ore mining and other mining	35 Electric current
31	Manufacturing of food, beverages, and tobacco (FOD)	311/312	Food manufacturing	01 Meat and meat preparations 1/
				02 Dairy products and birds' eggs 1/
				03 Fish, crustaceans, molluscs, and preparations thereof 1/
				04 Cereals and cereal preparations 1/
				05 Vegetables and fruit 1/
				06 Sugar, sugar preparations, and honey 1/
				07 Coffee, tea, cocoa, spices, and manufactures thereof 1/
				08 Feeding stuff for animals, excluding unmilled cereals
				09 Miscellaneous edible products and preparations
				22 Oil seeds and oleaginous fruit
				4 Animal and vegetable oils, fats, and waxes
		313	Beverage industries	11 Beverages
		314	Tobacco manufactures	12 Tobacco and tobacco manufactures
32	Textiles, wearing apparel, and leather industries (TEX)	321	Manufacture of textiles	21 Hides, skins and fur skins, raw
		322	Manufacture of wearing apparel except footwear	26 Textile fibers (except wool tops) and their wastes
				65 Textile yarn, fabrics, made-up articles, and related products
				84 Articles of apparel and clothing accessories
		323	Manufacture of leather and products of leather	61 Leather, leather manufactures, n.e.s., and dressed fur skins
		324	Manufacture of footwear	85 Footwear
34	Manufacturing of paper, and paper products (PAP)	341	Manufacture of paper and paper products	25 Pulp and waste paper
				64 Paper, paperboard, articles of paper, and paper-pulp/board
		342	Printing and publishing	

Source: Created by author.

Table 1. (Continued) Concordance Between Industry Data (ISDB) and Trade Data (ITCS)

International Sectoral Data Base (ISDB) at the two-digit ISIC level			International Trade by Commodities Statistics (ITCS) at the two-digit SITC level	
35	Manufacturing of chemicals and of chemical, petroleum, coal, rubber, and plastic rubber products (CHE)	351/352	Manufacture of industrial chemicals and other chemical products	27 Crude fertilizers and crude materials (excluding coal)
		353/354	Petroleum refineries and manufacture of miscellaneous products of petroleum, and coal	5 Chemicals and related products, n.e.s.
		356	Manufacture of plastic products	
		355	Manufacture of rubber products	23 Crude rubber (including synthetic and reclaimed) 62 Rubber manufactures, n.e.s.
36	Manufacturing of nonmetallic products, except petroleum and coal products (MNM)	361	Manufacture of pottery, china, and earthenware	66 Nonmetallic mineral manufactures, n.e.s.
		362	Manufacture of glass and glass products	
		369	Manufacture of other nonmetallic mineral products	
37	Basic metal industries (BMI)	371	Iron and steel basic industries	28 Metalliferous ores and metal scrap 67 Iron and steel
		372	Nonferrous metal basic industries	68 Nonferrous metals
38	Manufacturing of fabricated metal products, machinery, and equipment (MEQ)	381	Manufacture of fabricated metal products, except machinery and equipment	69 Manufactures of metal, n.e.s.
		382	Manufacture of machinery except electrical	71 Power-generating machinery and equipment 72 Machinery specialized for particular industries 73 Metalworking machinery 74 General industrial machinery and equipment, and parts
		383	Manufacture of electrical machinery, apparatus, appliances, and supplies	76 Telecommunications and sound recording apparatus 77 Electrical machinery, apparatus, and appliances, n.e.s. 81 Sanitary, plumbing, heating, and lighting fixtures
		384	Manufacture of transport equipment	78 Road vehicles (including air-cushion vehicles) 79 Other transport equipment
		385	Manufacture of professional and scientific, and measuring and controlling equipment	75 Office machines and automatic data processing equipment 87 Professional, scientific, and controlling instruments 88 Photographic apparatus, optical goods, and watches
39	Other manufacturing industries (MOT)	39	Other manufacturing industries	82 Furniture and parts thereof 83 Travel goods, handbags, and similar containers 89 Miscellaneous manufactured articles, n.e.s.

1/ Goods in these classifications are allocated into two industries, agriculture and the food products industry (see Table 2).

Table 2. Concordance Between Industry Data (ISDB) and Trade Data (ITCS): Supplement 1/

Industry Data (ISDB) at the two-digit ISIC level		Trade Data (ITCS) at the three-digit SITC level	
1 AGR	01	011	Meat, edible meat offals, fresh, chilled or frozen
31 FOD		012	Meat & edible offals, salted, in brine, dried/smoked
31 FOD		014	Meat & edible offals, prep./pres., fish extracts
1 AGR	02	022	Milk and cream
31 FOD		023	Butter
31 FOD		024	Cheese and curd
1 AGR		025	Eggs and yolks, fresh, dried or otherwise preserved
1 AGR	03	034	Fish, fresh (live or dead), chilled or frozen
31 FOD		035	Fish, dried, salted or in brine smoked fish
1 AGR		036	Crustaceans and molluscs, fresh, chilled, frozen etc.
31 FOD		037	Fish, crustaceans and molluscs, prepared or preserved
1 AGR	04	041	Wheat (including spelt) and meslin, unmilled
1 AGR		042	Rice
1 AGR		043	Barley, unmilled
1 AGR		044	Maize (corn), unmilled
1 AGR		045	Cereals, unmilled (no wheat, rice, barley or maize)
31 FOD		046	Meal and flour of wheat and flour of meslin
31 FOD		047	Other cereal meals and flours
31 FOD		048	Cereal preparations & preparations of flour of fruits or vegetables
1 AGR	05	054	Vegetables, fresh, chilled, frozen/preserved; roots, tubers
31 FOD		056	Vegetables, roots & tubers, prepared/preserved, n.e.s.
1 AGR		057	Fruit & nuts (not including oil nuts), fresh or dried
31 FOD		058	Fruit, preserved, and fruit preparations
1 AGR	06	061	Sugar and honey
31 FOD		062	Sugar confectionery and other sugar preparations
1 AGR	07	071	Coffee and coffee substitutes
1 AGR		072	Cocoa
31 FOD		073	Chocolate & other food preparations containing cocoa
1 AGR		074	Tea and mate
1 AGR		075	Spices

Source: Created by author.

1/ We need to divide import data at the two-digit SITC into two different industries at the two-digit ISIC level. For example, trade data classified as “Meat and meat preparation" (SITC 01) include both raw meat (which should be classified as agriculture) and processed meat (which should be classified as the food products industry). We take a very simply method. For example, we first compute the share of country A's imports of processed meat products using multilateral trade data (e.g., the share of imports of meat and edible offal, salted, in brine, dried or smoked (SITC 012) and of meat and edible offal, prepared or preserved, fish extracts (SITC 014) in total imports of meat and meat preparation (SITC 01)). We then use this share to compute country A's imports of processed meat products from country B (e.g., country A’s imports of meat and meat preparation (SITC 01) from country B times the share).

Table 3. The Final and the Intermediate Demand in Gross Output

ISIC code	ISIC definition	Country										No. of Countries with Share > 0.66
		AUS	CAN	DNK	FRA	DEU	ITA	JPN	NLD	GBR	USA	
The Share of Intermediate Demand in Gross Output 1/												
1	**Agriculture, forestry & fishing**	0.56	0.71	0.70	0.63	0.69	0.70	0.77	0.66	0.66	0.78	**7**
2	**Mining & quarrying**	0.52	0.58	0.76	0.85	0.96	0.88	1.00	0.73	0.65	0.86	**7**
31	Food, beverages & tobacco	0.24	0.32	0.24	0.25	0.31	0.34	0.33	0.32	0.36	0.33	0
32	Textiles, apparel & leather	0.37	0.36	0.24	0.32	0.28	0.33	0.41	0.24	0.36	0.39	0
33	Wood products & furniture	0.56	0.48	0.42	0.44	0.39	0.50	0.82	0.52	0.57	0.57	1
34	**Paper, paper products & printing**	0.74	0.53	0.69	0.68	0.77	0.74	0.88	0.62	0.74	0.67	**8**
351	Industrial chemicals	0.81	0.65	0.61	0.53	0.56	0.70	0.79	0.44	0.50	0.70	4
352	Drugs & medicines	0.64	0.20	0.18	0.10	na	0.32	0.68	0.25	0.53	0.35	2
353-4	Petroleum & coal products	0.60	0.54	0.77	0.42	0.48	0.59	0.74	0.34	0.44	0.47	2
355-6	**Rubber & plastic products**	0.79	0.71	0.51	0.69	0.62	0.68	0.87	0.58	0.73	0.78	**7**
36	**Non-metallic mineral products**	0.93	0.82	0.75	0.73	0.76	0.76	0.91	0.72	0.80	0.86	**10**
371	**Iron & steel**	0.85	0.92	0.73	0.76	0.80	0.79	0.94	0.56	0.79	0.95	**9**
372	**Non-ferrous metals**	0.48	0.46	0.74	0.69	0.73	0.93	0.92	na	0.68	0.90	**8**
381	Metal products	0.70	0.67	0.55	0.66	0.64	0.61	0.84	0.53	0.47	0.85	4
382	Non-electrical machinery	0.32	0.32	0.29	0.23	0.27	0.24	0.30	0.30	0.36	0.37	0
385	Office & computing machinery	na	0.24	na	0.25	0.20	0.19	0.18	0.22	0.18	0.20	2
383	Electrical apparatus, n.e.c.	0.48	0.55	0.54	0.39	0.36	0.47	0.50	0.32	0.41	0.58	0
383	Radio, TV & communication	0.36	0.39	0.23	0.35	na	0.30	0.43	na	0.33	0.42	2
384	Shipbuilding & repairing	0.07	0.24	0.19	0.24	0.08	0.62	0.20	0.21	0.30	0.07	0
384	Other transport	0.52	0.29	0.14	0.17	na	0.14	0.33	0.19	0.18	0.20	1
384	Motor vehicles	0.33	0.29	na	0.18	0.22	0.20	0.48	0.16	0.23	0.29	1
384	Aircraft	0.19	0.34	na	0.23	0.23	0.44	0.26	0.23	0.24	0.23	1
385	Professional goods	0.34	0.41	0.22	0.24	0.29	0.25	0.25	0.26	0.34	0.29	0
39	Other manufacturing	0.40	0.29	0.20	0.13	0.38	0.09	0.38	0.30	0.15	0.22	0
	Total	0.40	0.43	0.35	0.39	0.43	0.43	0.47	0.36	0.43	0.41	

Source: Created by author using the OECD STAN Input-Output Database for 1990 for all except AUS, ITA and NLD. The input-output tables from 1989, 1985 and 1986, are used for these countries, respectively.

Table 3. (Continued) The Final and the Intermediate Demand in Gross Output

ISIC code	ISIC definition	Country										No. of Countries with Share > 0.66
		AUS	CAN	DNK	FRA	DEU	ITA	JPN	NLD	GBR	USA	
The Share of Final Demand in Gross Output 2/												
1	Agriculture, forestry & fishing	0.44	0.29	0.30	0.37	0.31	0.30	0.23	0.34	0.34	0.22	0
2	Mining & quarrying	0.48	0.42	0.24	0.15	0.04	0.12	0.00	0.27	0.35	0.14	0
31	**Food, beverages & tobacco**	0.76	0.68	0.76	0.75	0.69	0.66	0.67	0.68	0.64	0.67	**9**
32	**Textiles, apparel & leather**	0.63	0.64	0.76	0.68	0.72	0.67	0.59	0.76	0.64	0.61	**5**
33	Wood products & furniture	0.44	0.52	0.58	0.56	0.61	0.50	0.18	0.48	0.43	0.43	0
34	Paper, paper products & printing	0.26	0.47	0.31	0.32	0.23	0.26	0.12	0.38	0.26	0.33	0
351	Industrial chemicals	0.19	0.35	0.39	0.47	0.44	0.30	0.21	0.56	0.50	0.30	0
352	**Drugs & medicines**	0.36	0.80	0.82	0.90	na	0.68	0.32	0.75	0.47	0.65	**6**
353-4	Petroleum & coal products	0.40	0.46	0.23	0.58	0.52	0.41	0.26	0.66	0.56	0.53	1
355-6	Rubber & plastic products	0.21	0.29	0.49	0.31	0.38	0.32	0.13	0.42	0.27	0.22	0
36	Non-metallic mineral products	0.07	0.18	0.25	0.27	0.24	0.24	0.09	0.28	0.20	0.14	0
371	Iron & steel	0.15	0.08	0.27	0.24	0.20	0.21	0.06	0.44	0.21	0.05	0
372	Non-ferrous metals	0.52	0.54	0.26	0.31	0.27	0.07	0.08	na	0.32	0.10	1
381	Metal products	0.30	0.33	0.45	0.34	0.36	0.39	0.16	0.47	0.53	0.15	0
382	**Non-electrical machinery**	0.68	0.68	0.71	0.77	0.73	0.76	0.70	0.70	0.64	0.63	**8**
385	**Office & computing machinery**	na	0.76	na	0.75	0.80	0.81	0.82	0.78	0.82	0.80	**10**
383	Electrical apparatus, n.e.c.	0.52	0.45	0.46	0.61	0.64	0.53	0.50	0.68	0.59	0.42	1
383	**Radio, TV & communication**	0.64	0.61	0.77	0.65	na	0.70	0.57	na	0.67	0.58	**5**
384	**Shipbuilding & repairing**	0.93	0.76	0.81	0.76	0.92	0.38	0.80	0.79	0.70	0.93	**9**
384	**Other transport**	0.48	0.71	0.86	0.83	na	0.86	0.67	0.81	0.82	0.80	**9**
384	**Motor vehicles**	0.67	0.71	na	0.82	0.78	0.80	0.52	0.84	0.77	0.71	**9**
384	**Aircraft**	0.81	0.66	na	0.77	0.77	0.56	0.74	0.77	0.76	0.77	**9**
385	**Professional goods**	0.66	0.59	0.78	0.76	0.71	0.75	0.75	0.74	0.66	0.71	**8**
39	**Other manufacturing**	0.60	0.71	0.80	0.87	0.62	0.91	0.62	0.70	0.85	0.78	**7**
	Total	0.60	0.57	0.65	0.61	0.57	0.57	0.53	0.64	0.57	0.59	

1/ If an industry has more than half of the countries in the sample with the share of intermediate demand greater than 2/3, then we call such an industry as the intermediate inputs industry (see industries in bold).
2/ If an industry has more than half of the countries in the sample with the share of final demand greater than 2/3, then we call such an industry as the final/consumption goods industry (see industries in bold).

Table 4. Group Mean Unit Roots and Cointegration Tests for Individual Countries

Country	Unit Root Tests 1/				Cointegration Tests 2/	
	Regression equation (16)		Regression equation (17)		Regression equation (16)	Regression equation (17)
	$\ln(M_i/D_i)$	Weighted $\ln(c_j/c_i)$	$\ln(M_{ij}/M_{ik})$	$\ln(c_j/c_k)$		
1. Agriculture, hunting, forestry, and fishing (AGR)						
AUS	-3.24	-2.26	-1.37	-1.34		-5.93 *
BEL	-1.59	-2.42	-2.02 *	-1.52		-9.20 *
CAN	-4.51	-3.09	-8.27 *	3.21		-5.78 *
DNK	-1.64	-0.05	4.55	-1.40		-2.15 *
FRA	-2.89	-2.34	-1.61	-1.03		-6.78 *
FIN	-2.89	-1.43	-6.37 *	0.59		-21.57 *
DEU	-1.68	-1.94	-7.38 *	0.54		-6.22 *
ITA	1.31	1.38	2.76	-5.81 *		-6.67 *
JPN	-2.47	-2.23	-2.98 *	-1.41		-8.02 *
NLD	-3.80	-1.68	-6.93 *	-1.06		-7.83 *
NOR	-3.01	-1.58	-1.54	3.15		-14.87 *
SWE	-2.26	-3.46	-2.45 *	-1.36		-11.76 *
GBR	-9.82	-2.44	-5.49 *	1.81		-7.05 *
USA	-1.85	-2.85	-0.70	2.63		-4.92 *
Group mean	**-5.95 ***	**-1.53**	**-10.67 ***	**-1.00**	**-4.76 ***	**-31.24 ***
2. Mining and quarrying (MID)						
AUS	-2.98	-3.24	-3.09 *	-0.12		-10.09 *
BEL						
CAN	-1.78	-2.10	-5.40 *	1.45		-15.37 *
DNK	-0.92	-3.36	1.73	-6.33 *		-2.69 *
FRA	-2.08	-2.80	-0.36	-4.96 *		-4.69 *
FIN	-7.08	-0.31	-4.07 *	-2.66 *		
DEU	-0.14	1.78	-0.78	2.27		-5.77 *
ITA						
JPN	-2.43	-1.98	-6.20 *	-0.78		-15.59 *
NLD	-3.21	-3.88	2.36 *	-10.75 *		
NOR	-4.56	-4.75	-5.26 *	-13.88 *		
SWE	-2.26	-4.63	-4.75 *	-3.40 *		
GBR	-1.87	-2.24	-7.47 *	-5.67 *		
USA	-3.41	-3.36	-1.42	3.89		-4.72 *
Group mean	**-4.88 ***	**-4.24 ***	**-10.04 ***	**-12.06 ***		

Source: Author's estimates.

Table 4. (Continued) Group Mean Unit Roots and Cointegration Tests for Individual Countries

Country	Unit Root Tests 1/				Cointegration Tests 2/	
	Regression equation (16)		Regression equation (17)		Regression equation (16)	Regression equation (17)
	$\ln(M_i/D_i)$	Weighted $\ln(c_j/c_i)$	$\ln(M_{ij}/M_{ik})$	$\ln(c_j/c_k)$		
31. Manufacturing of food, beverages, and tobacco (FOD)						
AUS						
BEL	-1.70	-1.63	-0.53	1.30		-7.88 *
CAN	-2.14	-2.18	-3.19 *	2.55		-11.25 *
DNK	-2.30	-0.43	-1.12	2.52		-3.15 *
FRA	-0.79	0.58	-2.87 *	2.20		-12.35 *
FIN	-1.00	-1.84	0.37	1.90		-8.56 *
DEU	-1.51	-0.86	-2.37 *	1.32		-7.93 *
ITA	-1.23	-1.61	4.09	-1.75		-6.39 *
JPN	-0.09	0.46	-0.97	6.25		-13.74 *
NLD						
NOR	-0.20	-0.18	-2.37 *	-1.47		-7.85 *
SWE	-0.96	-0.86	-7.28 *	-0.95		-6.84 *
GBR	-0.28	2.71	-1.26	4.79		-5.08 *
USA	-0.41	-2.43	-1.52	1.60		-4.18 *
Group mean	**2.01**	**3.49**	**-5.46 ***	**5.86**	**-6.45 ***	**-27.58 ***
32. Textiles, wearing apparel, and leather industries (TEX)						
AUS						
BEL	-5.73	-2.19	-4.42 *	1.32		-9.16 *
CAN	-0.42	-0.93	1.95	-0.86		-2.56 *
DNK	-0.21	-0.38	0.05	-2.70 *		-2.42 *
FRA	-3.35	-1.85	-1.98	-1.36		-2.73 *
FIN	0.21	0.72	1.61	-0.20		-4.08 *
DEU	-3.00	-2.13	-1.72	-1.38		-2.02 *
ITA	-1.24	-2.01	-4.61 *	-2.85 *		
JPN	-1.10	-0.27	-4.54 *	-2.50 *		
NLD						
NOR	-3.70	-3.61	-0.05	-0.64		-3.32 *
SWE	-1.47	-2.16	0.13	-1.05		-2.86 *
GBR	-3.76	-1.76	0.90	-0.35		-2.94 *
USA	0.31	-2.91	1.90	0.12		-3.28 *
Group mean	**-1.70**	**-0.35**	**-3.19 ***	**-4.30 ***	**-2.01 ***	

Table 4. (Continued) Group Mean Unit Roots and Cointegration Tests for Individual Countries

Country	Unit Root Tests 1/				Cointegration Tests 2/	
	Regression equation (16)		Regression equation (17)		Regression equation (16)	Regression equation (17)
	$\ln(M_i/D_i)$	Weighted $\ln(c_j/c_i)$	$\ln(M_{ij}/M_{ik})$	$\ln(c_j/c_k)$		
34. Manufacturing of paper and paper products (PAP)						
AUS						
BEL	-2.55	-2.77	-0.85	1.52		-4.03 *
CAN	-1.55	-1.12	-6.52 *	1.76		-6.19 *
DNK	-0.90	0.00	5.19	-1.80		-6.40 *
FRA	0.53	-1.72	-2.39 *	1.03		-3.22 *
FIN	-1.16	-1.57	-2.53 *	-0.85		-7.52 *
DEU	-1.89	1.89	-1.26	0.65		-3.60 *
ITA						
JPN	-2.10	-0.35	-9.59 *	-0.82		-18.25 *
NLD						
NOR	-2.41	-2.95	-3.58 *	0.58		-11.90 *
SWE	1.47	-3.26	-1.53	0.70		-6.59 *
GBR	-2.30	-1.62	-1.72	0.36		-3.00 *
USA	-0.55	-0.94	1.37	1.43		-5.98 *
Group mean	**1.27**	**0.9**	**-7.48 ***	**1.32**	**-2.29 ***	**-20.50 ***
35. Manufacturing of chemicals and of chemical, petroleum, coal, rubber, and plastic rubber (CHE)						
AUS						
BEL	-1.35	-3.99	-5.83 *	0.14		-5.92 *
CAN	0.33	-1.13	-5.77 *	1.17		-11.87 *
DNK	-1.08	-1.77	-0.59	0.87		-8.03 *
FRA	-1.65	-2.38	-1.28	1.56		-6.32 *
FIN	-1.70	-3.38	-2.81 *	0.36		-5.12 *
DEU	-1.37	3.53	0.23	-0.07		-2.29 *
ITA	-2.52	-1.97	0.30	0.76		-3.61 *
JPN	-2.04	-1.56	0.83	-1.39		-6.27 *
NLD						
NOR	-0.27	-2.79	-6.55 *	2.70		-13.23 *
SWE	-1.98	-2.78	-3.53 *	2.03		-7.23 *
GBR	-3.62	-0.51	-4.12 *	2.02		-9.46 *
USA	-2.37	-3.69	-7.29 *	1.51		-11.42 *
Group mean	**-0.40**	**-1.35**	**-10.39 ***	**3.35**	**-1.99 ***	**-26.09 ***

Table 4. (Continued) Group Mean Unit Roots and Cointegration Tests for Individual Countries

Country	Unit Root Tests 1/				Cointegration Tests 2/	
	Regression equation (16)		Regression equation (17)		Regression equation (16)	Regression equation (17)
	$\ln(M_i/D_i)$	Weighted $\ln(c_j/c_i)$	$\ln(M_{ij}/M_{ik})$	$\ln(c_j/c_k)$		
36. Manufacturing of nonmetallic mineral products, except petroleum and coal products (MNM)						
AUS						
BEL	-2.88	-0.26	11.75 *	-6.32 *		
CAN	-2.84	-2.02	2.78	-7.30 *		-6.06 *
DNK	-0.74	2.50	-6.04 *	-8.46 *		
FRA	-1.57	-2.88	-5.50 *	-3.75 *		
FIN	-1.24	-1.25	0.20	-4.02 *		-5.33 *
DEU	-0.89	-10.00	-10.63 *	-4.25 *		
ITA	-1.34	-2.65	-5.90 *	-2.31 *		
JPN	-0.58	-2.61	-1.29	-2.56 *		-9.88 *
NLD						
NOR						
SWE	-1.11	-1.68	-4.51 *	-5.41 *		
GBR	-1.91	-1.58	-5.90 *	-4.79 *		
USA	-1.13	-0.76	-0.56	-4.49 *		-2.83 *
Group mean	**0.24**	**-2.24** *	**0.56**	**-9.18** *	**-2.40** *	
37. Basic metal industries (BMI)						
AUS						
BEL	-1.85	-2.41	-1.08	-0.96		-5.23 *
CAN	-1.52	-3.84	-6.96 *	-0.80		-12.24 *
DNK	-3.39	-3.44	-2.98 *	-0.46		-6.03 *
FRA	-2.19	-0.52	-0.86	-0.71		-8.72 *
FIN	-3.57	9.72	-4.93 *	-0.19		-11.57 *
DEU	-1.19	-3.20	-1.70	0.13		-7.33 *
ITA	-2.50	-1.51	-0.40	-0.14		-8.29 *
JPN	-0.62	-1.45	-9.81 *	-1.47		-16.27 *
NLD						
NOR	-1.95	-3.95	-9.54 *	-1.98		-12.14 *
SWE	-3.54	-1.03	-3.23 *	0.06		-10.59 *
GBR	-1.59	1.04	-8.46 *	-1.07		-12.95 *
USA	-3.49	-1.89	-6.42 *	-0.82		-17.73 *
Group mean	**-3.06** *	**2.06**	**-16.22** *	**2.41**	**-4.36** *	

Table 4. (Continued) Group Mean Unit Roots and Cointegration Tests for Individual Countries

Country	Unit Root Tests 1/				Cointegration Tests 2/	
	Regression equation (16)		Regression equation (17)		Regression equation (16)	Regression equation (17)
	$\ln(M_i/D_i)$	Weighted $\ln(c_j/c_i)$	$\ln(M_{ij}/M_{ik})$	$\ln(c_j/c_k)$		
38. Manufacturing of fabricated metal products, machinery, and equipment (MEQ)						
AUS						
BEL	-2.57	0.18	1.76	3.29		-8.13 *
CAN	-4.06	-1.34	-6.00 *	4.21		-12.65 *
DNK	-0.70	0.41	-2.30 *	2.67		-7.89 *
FRA	-0.93	-2.70	2.40	4.84		-10.58 *
FIN	-0.52	-2.90	-0.26	2.97		-8.73 *
DEU	-1.97	-3.07	-1.61	5.23		-6.30 *
ITA	0.20	1.41	-1.82	2.86		-13.07 *
JPN	-1.25	0.07	-1.70	3.60		-11.76 *
NLD						
NOR	-1.92	-3.32	-5.55 *	9.26		-17.15 *
SWE	-1.20	-1.80	-2.72 *	4.79		-4.34 *
GBR	-3.83	-1.45	-4.00 *	4.42		-6.84 *
USA	-3.33	-0.45	-2.16 *	5.83		-9.29 *
Group mean	**1.23**	**1.20**	**-6.83 ***	**15.54**	**-2.10 ***	**-33.70 ***
39. Other manufacturing industries (MOT)						
AUS						
BEL	-0.99	-3.00	-1.36	-0.57		-7.83 *
CAN	0.18	-0.88	-1.20	-0.50		-3.75 *
DNK	-1.44	-0.99	-1.30	-0.19		-8.22 *
FRA						
FIN	-1.14	-2.37	-3.07 *	0.05		-4.86 *
DEU	-1.46	-0.83	-2.11 *	0.15		-3.92 *
ITA	-0.84	0.53	-4.90 *	-3.69 *		
JPN	1.02	-2.06	-11.39 *	-1.65		-10.81 *
NLD						
NOR						
SWE	-1.98	-1.90	-0.43	0.98		-3.56 *
GBR	-1.53	-1.50	-1.56	-0.25		-2.64 *
USA	-1.15	-0.44	-1.91	-0.43		-2.42 *
Group mean	**2.28**	**0.73**	**-8.11 ***	**-0.80**	**-2.14 ***	**-13.71 ***

1/ The null of unit root tests is "unit roots." The asterisk next to the t-bar statistics indicates that the null is rejected (test statistics for the individual countries in columns 2 and 3 are not t-bar statistics, but are test statistics for individual time series). Heterogeneous lag truncation is applied (up to the maximum lag of 7). No time-specific dummies are included since there is no reasons why time-specific events such as oil shocks can affect trade patterns or labor productivity in the same manner across all countries.
2/ The null of cointegration tests is "no cointegration." The asterisk next to the group Augmented Dicky-Fuller (ADF) statistics indicates that the null is rejected. The cointegration tests are implemented only in cases where at least one variable is non-stationary. Heterogeneous lag truncation is applied though not reported in this table (up to the maximum lag of 3). No time-specific dummies are included.

Table 5. The Panel FMOLS Estimates for Individual Countries

Country	FMOLS Estimates 1/						Wald Tests 2/
	Inter-group elasticity			Intra-group elasticity			
	σ	Std. Errors	Number of *i*	σ_s	Std. Errors	Number of *ijk*	
1. Agriculture, hunting, forestry, and fishing (AGR)							
AUS	**-0.55**	1.78	1	**-1.81**	0.31	76	0.49
BEL	**24.24**	5.21	1	**-14.72**	1.48	76	51.80 *
CAN	**-0.60**	0.98	1	**0.15**	0.33	74	0.53
DNK	**5.11**	1.44	1	**0.08**	0.42	74	11.22 *
FRA	**-10.27**	2.41	1	**-1.83**	0.48	74	11.79 *
FIN	**4.67**	0.83	1	**0.14**	0.46	74	22.95 *
DEU	**6.43**	1.49	1	**-0.37**	0.38	74	19.46 *
ITA	**0.61**	0.27	1	**0.91**	0.25	76	0.67
JPN	**2.23**	0.43	1	**5.17**	0.48	75	21.15 *
NLD	**0.62**	0.54	1	**-2.48**	0.51	76	17.66 *
NOR	**3.25**	1.56	1	**1.12**	0.69	74	1.55
SWE	**5.18**	1.21	1	**1.31**	0.13	74	10.00 *
GBR	**3.20**	1.07	1	**2.24**	0.30	74	0.75
USA	**5.24**	2.70	1	**-1.86**	0.31	62	6.82 *
Group mean	**3.53**	**0.53**	**14**	**0.24**	**0.11**	**957**	36.84 *
2. Mining and quarrying (MID)							
AUS	**2.61**	0.42	1	**0.50**	0.22	55	20.07 *
BEL							
CAN	**0.44**	1.58	1	**3.47**	0.31	55	3.56
DNK	**2.73**	0.59	1	**1.14**	0.12	55	6.96 *
FRA	**0.88**	0.27	1	**0.81**	0.04	55	0.05
FIN	**1.17**	0.10	1				136.49
DEU	**1.45**	0.09	1	**0.82**	0.03	55	48.30 *
ITA							
JPN	**1.90**	0.17	1	**0.65**	0.17	60	27.15 *
NLD	**1.21**	0.21	1				34.22
NOR	**5.32**	0.85	1				38.91
SWE	**1.27**	0.25	1				27.01
GBR	**3.54**	0.44	1				63.48
USA	**2.32**	0.45	1	**-0.34**	0.23	45	28.29 *
Group mean	**2.07**	**0.17**	**12**	**1.04**	**0.07**	**380**	30.35 *

Source: Author's estimates.

Table 5. (Continued) The Panel FMOLS Estimates for Individual Countries

Country	FMOLS Estimates 1/						Wald Tests 2/
	Inter-group elasticity			Intra-group elasticity			
	σ	Std. Errors	Number of *i*	σ_s	Std. Errors	Number of *ijk*	
31. Manufacturing of food, beverages, and tobacco (FOD)							
AUS							
BEL	**1.28**	0.91	1	**3.66**	0.37	55	5.87 *
CAN	**2.12**	0.98	1	**1.26**	0.27	55	0.71
DNK	**2.28**	0.55	1	**1.50**	0.36	55	1.44
FRA	**1.18**	0.20	1	**0.73**	0.30	55	1.61
FIN	**2.91**	0.62	1	**-1.14**	0.29	55	34.74 *
DEU	**1.79**	0.45	1	**1.98**	0.43	55	0.09
ITA	**2.20**	0.30	1	**1.76**	0.27	55	1.21
JPN	**-1.78**	0.90	1	**-0.12**	0.89	55	1.71
NLD							
NOR	**-1.25**	0.22	1	**2.40**	0.33	55	84.03 *
SWE	**1.85**	0.41	1	**-0.50**	0.21	55	25.95 *
GBR	**1.00**	0.41	1	**-2.11**	0.50	55	22.77 *
USA	**-2.28**	0.81	1	**1.73**	0.44	45	18.94 *
Group mean	**0.94**	**0.18**	**12**	**0.92**	**0.12**	**650**	0.01
32. Textiles, wearing apparel, and leather industries (TEX)							
AUS							
BEL	**1.85**	0.79	1	**1.25**	0.15	55	0.57
CAN	**-3.33**	0.59	1	**2.31**	0.18	55	83.30 *
DNK	**1.12**	0.38	1	**1.84**	0.25	55	2.50
FRA	**-0.16**	0.18	1	**0.83**	0.14	55	18.52 *
FIN	**3.14**	0.20	1	**1.31**	0.11	55	64.97 *
DEU	**0.45**	0.08	1	**1.41**	0.12	55	46.82 *
ITA	**1.35**	0.26	1				27.69
JPN	**2.43**	0.37	1				42.60
NLD							
NOR	**1.63**	0.20	1	**1.36**	0.14	55	1.17
SWE	**0.17**	0.24	1	**0.98**	0.10	55	9.83 *
GBR	**2.88**	0.36	1	**0.69**	0.10	55	33.74 *
USA	**1.05**	0.96	1	**3.05**	0.18	45	4.24 *
Group mean	**1.05**	**0.13**	**12**	**1.39**	**0.06**	**540**	5.37 *

Table 5. (Continued) The Panel FMOLS Estimates for Individual Countries

Country	FMOLS Estimates 1/						Wald Tests 2/
	Inter-group elasticity			Intra-group elasticity			
	σ	Std. Errors	Number of *i*	σ_s	Std. Errors	Number of *ijk*	
34. Manufacturing of paper and paper products (PAP)							
AUS							
BEL	**2.58**	0.32	1	**0.78**	0.17	45	24.63 *
CAN	**1.83**	1.51	1	**1.22**	0.57	45	0.14
DNK	**0.98**	0.31	1	**0.75**	0.36	45	0.23
FRA	**1.96**	0.17	1	**1.15**	0.18	45	10.48 *
FIN	**1.78**	0.44	1	**1.02**	0.54	45	1.16
DEU	**0.24**	0.33	1	**0.66**	0.15	45	1.31
ITA							
JPN	**6.82**	0.97	1	**-2.76**	0.90	49	52.36 *
NLD							
NOR	**2.17**	0.13	1	**0.91**	0.25	45	19.42 *
SWE	**1.43**	0.20	1	**2.56**	0.39	45	6.70 *
GBR	**1.55**	0.09	1	**0.22**	0.18	45	45.10 *
USA	**0.79**	0.53	1	**1.91**	0.33	36	3.27
Group mean	**2.01**	**0.18**	**11**	**0.72**	**0.13**	**490**	32.42 *
35. Manufacturing of chemicals and of chemical, petroleum, coal, rubber, and plastic rubber (CHE)							
AUS							
BEL	**1.11**	0.55	1	**2.16**	0.19	55	3.27
CAN	**3.62**	0.82	1	**0.97**	0.18	55	9.92 *
DNK	**3.34**	0.36	1	**0.29**	0.23	55	50.72 *
FRA	**2.89**	0.51	1	**0.80**	0.17	55	15.21 *
FIN	**2.17**	0.75	1	**2.61**	0.15	55	0.32
DEU	**1.68**	0.45	1	**-0.31**	0.20	55	16.19 *
ITA	**0.98**	0.15	1	**1.79**	0.21	55	10.28 *
JPN	**5.76**	0.36	1	**0.49**	0.33	55	118.30 *
NLD							
NOR	**1.58**	0.23	1	**2.33**	0.15	55	7.57 *
SWE	**0.42**	0.34	1	**1.21**	0.15	55	4.38 *
GBR	**2.06**	1.76	1	**-0.28**	0.12	55	1.76
USA	**1.94**	0.56	1	**1.96**	0.21	45	0.00
Group mean	**2.30**	**0.20**	**12**	**1.16**	**0.06**	**650**	29.48 *

Table 5. (Continued) The Panel FMOLS Estimates for Individual Countries

Country	FMOLS Estimates 1/						Wald Tests 2/
	Inter-group elasticity			Intra-group elasticity			
	σ	Std. Errors	Number of *i*	σ_s	Std. Errors	Number of *ijk*	
36. Manufacturing of nonmetallic mineral products, except petroleum and coal products (MNM)							
AUS							
BEL	**1.89**	0.52	1				13.20
CAN	**-5.43**	1.31	1	**0.40**	0.18	45	19.51 *
DNK	**5.09**	1.07	1				22.68
FRA	**1.34**	0.27	1				24.96
FIN	**6.11**	1.17	1	**0.46**	0.35	45	21.40 *
DEU	**1.21**	0.21	1				34.55
ITA	**1.55**	0.17	1				84.00
JPN	**-1.03**	0.58	1	**0.06**	0.37	45	2.53
NLD							
NOR							
SWE	**3.24**	0.48	1				45.31
GBR	**-1.55**	1.77	1				0.77
USA	**0.11**	1.59	1	**1.31**	0.18	45	0.57
Group mean	**1.14**	**0.30**	**11**	**0.56**	**0.14**	**180**	3.07
37. Basic metal industries (BMI)							
AUS							
BEL	**1.10**	0.25	1	**2.22**	0.15	55	14.78 *
CAN	**2.01**	0.29	1	**1.98**	0.29	55	0.01
DNK	**2.14**	0.11	1	**0.15**	0.14	55	126.33 *
FRA	**2.50**	0.37	1	**1.01**	0.09	55	15.47 *
FIN	**3.49**	0.79	1	**-0.36**	0.27	55	21.49 *
DEU	**3.44**	0.70	1	**0.04**	0.08	55	23.30 *
ITA	**1.25**	0.32	1	**0.22**	0.14	55	8.75 *
JPN	**2.86**	0.84	1	**1.41**	0.44	55	2.33
NLD							
NOR	**1.68**	0.13	1	**0.10**	0.15	55	62.60 *
SWE	**2.08**	0.13	1	**0.87**	0.08	55	61.35 *
GBR	**0.84**	0.52	1	**0.29**	0.11	55	1.08
USA	**7.81**	1.13	1	**0.51**	0.13	45	41.37 *
Group mean	**2.60**	**0.16**	**12**	**0.71**	**0.06**	**650**	120.68 *

Table 5. (Continued) The Panel FMOLS Estimates for Individual Countries

Country	FMOLS Estimates 1/						Wald Tests 2/
	Inter-group elasticity			Intra-group elasticity			
	σ	Std. Errors	Number of *i*	σ_s	Std. Errors	Number of *ijk*	
38. Manufacturing of fabricated metal products, machinery, and equipment (MEQ)							
AUS							
BEL	**1.80**	0.95	1	**1.72**	0.12	55	0.01
CAN	**7.52**	1.98	1	**1.67**	0.18	55	8.65 *
DNK	**5.27**	0.92	1	**0.79**	0.16	55	23.18 *
FRA	**2.00**	0.49	1	**1.15**	0.17	55	2.69
FIN	**3.55**	1.08	1	**1.25**	0.17	55	4.45 *
DEU	**2.10**	0.48	1	**1.54**	0.10	55	1.30
ITA	**0.97**	0.16	1	**1.55**	0.16	55	6.78 *
JPN	**1.14**	0.37	1	**1.67**	0.34	55	1.16
NLD							
NOR	**1.00**	0.43	1	**1.13**	0.19	55	0.08
SWE	**2.60**	0.37	1	**0.71**	0.10	55	24.74 *
GBR	**2.33**	0.14	1	**1.00**	0.17	55	37.17 *
USA	**0.31**	0.86	1	**1.82**	0.18	45	3.01
Group mean	**2.55**	**0.24**	**12**	**1.33**	**0.05**	**650**	24.10 *
39. Other manufacturing industries (MOT)							
AUS							
BEL	**1.62**	0.12	1	**1.30**	0.13	36	3.49
CAN	**0.88**	0.10	1	**1.57**	0.14	36	16.45 *
DNK	**1.59**	0.19	1	**0.81**	0.13	36	11.47 *
FRA							
FIN	**1.20**	0.09	1	**0.95**	0.17	36	1.74
DEU	**1.02**	0.07	1	**0.48**	0.14	36	12.07 *
ITA	**0.63**	0.12	1				26.11
JPN	**1.53**	0.39	1	**1.32**	0.25	36	0.20
NLD							
NOR							
SWE	**0.99**	0.02	1	**0.94**	0.03	36	2.16
GBR	**0.05**	0.15	1	**0.96**	0.10	36	25.65 *
USA	**-0.14**	0.25	1	**2.00**	0.13	36	58.62 *
Group mean	**0.94**	**0.06**	**10**	**1.15**	**0.05**	**324**	7.97 *

1/ For panel FMOLS estimations of **inter-group elasticities**, time-specific dummies are included since time-specific events such as transport costs and tariff rates reductions are likely to have affected the substitutability of domestic to foreign goods in the same manner across all countries. For panel FMOLS estimations of **intra-group elasticities**, time-specific dummies are NOT included since time-specific events such as transport costs and tariff rates reductions would cancel out if the rate of reductions are the same across all exporting countries.
2/ The asterisk indicates that inter-group and intra-group elasticities are different with statistical significance of the 95 percent level.

Table 6. Group-Mean Panel FMOLS Estimates for the OECD Member Countries 1/

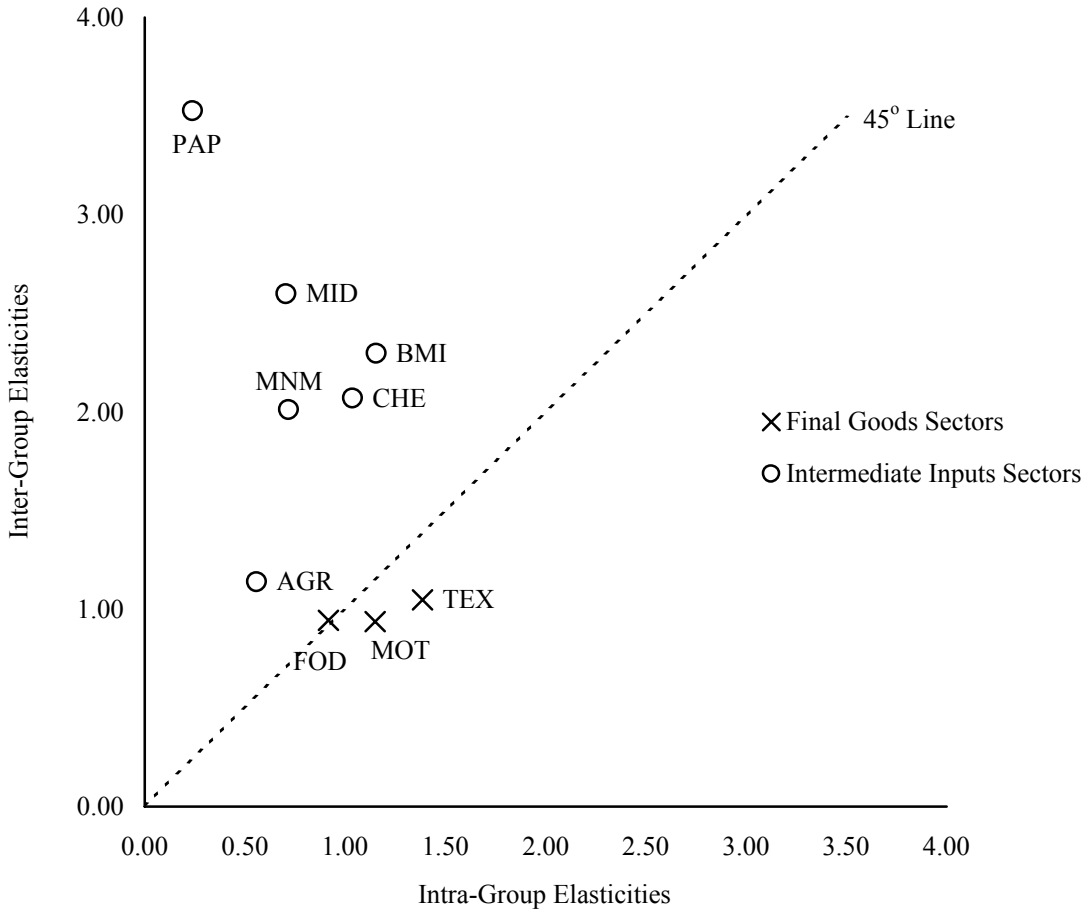
	Industry (the two-digit ISIC code)	Inter-group elasticity			Intra-group elasticity			Wald tests 2/
		σ	Std. Errors	Number of *i*	σ_s	Std. Errors	Number of *ijk*	
	Intermediate Inputs Sectors							
1	Agriculture, hunting, forestry, and fishing (AGR)	3.53	0.53	1	0.24	0.11	957	36.84 *
2	Mining and quarrying (MID)	2.07	0.17	1	1.04	0.07	380	30.35 *
34	Manufacturing of paper and paper products (PAP)	2.01	0.18	1	0.72	0.13	490	32.42 *
35	Manufacturing of chemicals and of chemical, petroleum, coal, rubber, and plastic rubber (CHE)	2.30	0.20	1	1.16	0.06	650	29.48 *
36	Manufacturing of nonmetallic mineral products, except petroleum and coal products (MNM)	1.14	0.30	1	0.56	0.14	180	3.07
37	Basic metal industries (BMI)	2.60	0.16	1	0.71	0.06	650	120.68 *
	Final Goods Sectors							
31	Manufacturing of food, beverages, and tobacco (FOD)	0.94	0.18	1	0.92	0.12	650	0.01
32	Textiles, wearing apparel, and leather industries (TEX)	1.05	0.13	1	1.39	0.06	540	5.37 *
39	Other manufacturing industries (MOT)	0.94	0.06	1	1.15	0.05	324	7.97 *
	Not Classified							
38	Manufacturing of fabricated metal products, machinery, and equipment (MEQ)	2.55	0.24	1	1.33	0.05	650	24.10 *

Source: Author's estimates.

1/ For the group-mean FMOLS estimates for the *inter-group elasticities* , see regression equations (14) or (16). For the group-mean FMOLS estimates for the *intra-group elasticities* , see regression equations (15) or (17).

2/ The asterisks indicate that inter-group and intra-group elasticities are different with statistical significance of the 95 percent level.

Figure 1. Intergroup Versus Intragroup Elasticities (OECD)



Source: Author's estimates.

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