Accounting for international trade

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Abstract

We develop a model to account for the volume and pattern of international trade. The model incorporates technological, factor endowment, and geographic differences at the industry level. In addition, within-industry heterogeneity gives rise to intra-industry trade, thus eliminating the need for the Armington assumption. We parametrize the model using data for eight industries in nineteen OECD countries. Evaluating the model, we find that it accurately predicts the magnitude and composition of trade flows. We also find that the effects of capital on specialization predicted by the model are close to those obtained by regression analysis. We use the model to identify the main determinants of the volume and composition of trade. We find that, given current trade barriers, within-industry heterogeneity accounts for 93% of the volume of trade, while industry-level comparative advantage and factor-endowment differences account for 4%. Technology, tastes, and factor endowments are responsible for 22% of inter-industry trade, while geography-related trade advantages are responsible for the remaining 78%.

JEL codes: F1, F11, F17, F21, O41

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1 Introduction

We develop a model of international trade with roles for technology, factor endowments, and distance. The model is computable and able to account for observed patterns and volumes of trade. It includes elements of the Eaton-Kortum, Ricardian, and Heckscher-Ohlin models, and Hirchman's notion of forward and backward linkages. We use the model to identify the main determinants of the volume and composition of trade.

Our model has neoclassical features, such as constant returns to scale in production, multiple industries, perfectly competitive markets for goods and services, and several factors that are mobile between industries (Harrigan, 2003). It is a large-country model, with countries trading both final

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and intermediate goods.[1] In the basic model, country capital stocks are fixed. Model extensions developed in Appendix C incorporate endogenous capital accumulation and an international capital market.

Countries have several reasons to trade in our framework. First, since industries have different factor intensities and countries have different relative factor endowments, the standard Heckscher-Ohlin motive applies. Second, as in Harrigan (1997), countries have different relative productivities across industries, giving them incentives to trade in order to exploit comparative advantage. Third, countries have different tastes. Fourth, within-industry heterogeneity, driven by productivity differences across goods, gives rise to intra-industry trade. Finally, trade is affected by geography and trade barriers.[2]

Our framework can be used as an alternative to CGE models that rely on the Armington (1969) assumption to explain intra-industry trade. Unlike those models, our framework does not require estimation of substitution elasticities between domestic and imported goods, nor does it give countries monopoly power over their products. It is much more compact and allows for trade growth on both extensive (greater variety) and intensive (greater quantity) margins.[3]

We parametrize our model using 1989 data on 8 two-digit industries in 19 OECD countries, including Mexico and Turkey. We then evaluate it by comparing 2,736 trade flows predicted by the model to the actual trade flows. In doing so, we find that the model is able to accurately predict the magnitude and composition of trade.

We evaluate the model further by comparing average effects of capital stock on specialization predicted by the model to those obtained by regression analysis (Harrigan, 1997).[4] We find that the results are very similar. In the course of this investigation, we also find that the effects of capital stock on specialization vary significantly across countries. The effects of technology on specialization, on the other hand, are far more consistent.

We then use the model to identify how the volume and composition of trade are determined by technology, factor endowments, tastes, geography, and within-industry heterogeneity. The intent of this investigation is similar to that of growth accounting. While growth accounting aims to determine how much each component of growth contributes to total growth, we want to find out how much each component of trade contributes to the volume as well as composition of trade. Unlike growth accounting, our methodology does not guarantee that we can explain all of trade. We are, however, able to account for almost all of it.

We find that within-industry heterogeneity is responsible for 93% of the volume trade. Differences in relative productivities across industries, which give rise to industry-level comparative advantages, are responsible for 5%. Thus, productivity differences on product and industry levels

[1] Countries that are 'large' can influence their own terms of trade.

[2] There are other models that combine several explanations of trade. Theoretical works by Dixit and Norman (1980), Helpman (1981), and Ethier (1982b) combine models of imperfect competition with the Heckscher-Ohlin model. Davis (1995) develops a model that combines the Heckscher-Ohlin model with the Ricardian model to explain intra-industry trade. Empirical studies that combine several explanations of trade include Trefler (1995) and Harrigan (1997). The former allows sector-neutral technological differences in the Heckscher-Ohlin model. The latter combines non-sector-neutral technological differences with factor endowment differences.

[3] The Armington (1969) assumption postulates that consumers see goods coming from different countries as different goods. This means that two-way trade exists even if industries are homogeneous. Several problems that occur due to the usage of this assumption have been pointed out in the literature. McDaniel and Balistreri (2003) discuss estimation of substitution elasticities. Brown (1987) and Panagariya and Duttagupta (2001) discuss problems that arise because countries have monopoly power over their products.

[4] Specialization is measured by industry shares in GDP.

together account for 98% of the volume of trade. Factor endowment differences have virtually no effect on the volume of trade, while taste differences across countries actually decrease trade by about 6%.[5]

Similarly, we are able to determine the effects of comparative advantage, factor endowments, and other determinants of trade on the size of inter-industry trade. We find that geography and differences of trade costs are responsible for 78% of inter-industry trade. Comparative advantages are responsible for 12%, taste differences, 8%, and factor endowment differences, the remaining 3%.

In addition to accounting for the volume and composition of trade, we also examine how determinants of trade influence the pattern of trade or net exports. We find that removing industry-level comparative advantages has a major effect on the pattern of trade, causing nearly a half of all trade flows to reverse direction. On the other hand, removing within-industry heterogeneity or differences of factor endowments has a much smaller effect.[6]

The remainder of the paper is structured as follows. Section 2 describes the model. Section 3 explains parameterization of the model and evaluates its fit. In Section 4, we use the model to account for the volume and composition of trade. Section 5 considers the effects of technology and factor endowments on specialization. Section 6 presents the conclusions.

Appendices contain the following information. Appendix A explains our notation by placing it in the context of a standard input-output table. Appendix B describes data sources. Appendix C develops extensions of the model that include endogenous capital accumulation and an international capital market. Appendix D employs model extensions developed in Appendix C to study the effects of technological improvement in the U.S. Machinery industry. Appendix E suggests an approach to estimating the technology parameter of the nontraded sector.

2 Computable model of international trade

Industries have long been the focus of analysis in international trade. They are usually characterized by a particular level of technology, set of factor intensities, and demand function. However, it has been found that individual products within an industry can be produced with very different productivities.[7] Our model combines these frameworks by creating two levels of heterogeneity within countries: one at the industry level, and the other at the product level within industry.

Within each industry, producers manufacture different goods, and the production processes for each good have different productivities. However, all producers within an industry draw from the same technology curve, have the same factor intensities, face the same demand shares for intermediate and final goods, and are subject to the same transport costs. In addition, all producers in all industries within a country face the same factor prices.

[5] We obtain these numbers by removing the determinants of trade one-by-one and noting the resulting changes in trade. For example, to find the effect of capital stock differences, we give all countries the same capital-labor ratio.

[6] We want to note that our conclusion about factor endowments having little effect on the volume or pattern of trade is achieved by looking only at the manufacturing sector and using only two factors: capital and labor. This conclusion may change if we include nonmanufacturing sectors, such as mining and agriculture, and other factors, such as land and other natural resources. Also, our conclusions regarding the importance of industry-level comparative advantage are based on analysis that uses a relatively low level of disaggregation (two-digit industries). Using more disaggregated data would probably give more influence to the industry-level comparative advantage and less to within-industry heterogeneity.

[7] See, for example, Bernard and Jensen (1995), Bernard and Jensen (1999), Aw, Chung and Roberts (1998), Clerides, Lach and Tybout (1998), Bernard, Eaton, Jensen and Kortum (2003), and Eaton, Kortum and Kramarz (2004).

We model technological differences at the product level following Eaton and Kortum (2002). By allowing product-level heterogeneity of productivities, the Eaton-Kortum (EK) model incorporates two-way trade of similar goods without requiring the Armington assumption. The EK model also allows for easy incorporation of asymmetric transport costs. This ability is crucial because transport costs have been shown to have a major influence on the pattern of international trade.[8,9]

The model we develop in this paper also takes into account the fact that a large portion of intermediate goods consumed by an industry come from other industries. As evidenced in Table 4, even with a coarse two-digit industry classification, only 20-50% of intermediate goods comes from own industry. In the terminology of Hirschman (1958), these are forward and backward linkages between industries. For example, higher demand for machinery products also increases demand for intermediate goods made by the metal-producing industry.

2.1 Description of the model

There are N countries and J industries. Subscripts i and n refer to countries, while subscripts j and m refer to industries. The industry cost function is

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \rho_{ij}^{1-\alpha_j-\beta_j}, \tag{1}$$

where r is return to capital, w is wage, and ρ is price of intermediate inputs. We assume that industries mix intermediate inputs in a Cobb-Douglas fashion, so that the price of inputs ρ_{ij} is the Cobb-Douglas function of industry prices:

$$\rho_{ij} = \prod_{m=1}^{J} p_{im}^{\eta_{jm}}. \tag{2}$$

In this expression, η_{jm} is the share of industry m goods in the input of industry j, such that $\sum_{m=1}^{J} \eta_{jm} = 1, \forall j$.

Intra-industry production, trade, and prices are modeled following Eaton and Kortum (2002). In each industry, there is a continuum of goods, each produced with its own productivity. Productivities are assigned probabilistically, drawn from the Fréchet distribution.[10] Consumers have CES preferences over these goods.[11]

Eaton and Kortum (2002) show how prices are determined given technology parameters, transport costs, and costs of production. The reader is referred to their paper for derivation. We take EK's price index equation and add industry dimension to it. As the result, the price index in industry j is

$$p_{nj} = \left[\sum_{i=1}^{N} T_{ij} \left(d_{nij} c_{ij} \right)^{-\theta} \right]^{-1/\theta}, \tag{3}$$

[8] For extensions of the Eaton-Kortum model see Bernard et al. (2003), who extend it to the Bertrand competition, and Eaton et al. (2004), who extend it to the Cournot competition. A good summary of Eaton and Kortum's ideas is given in Eaton and Kortum (2001a; 2005). Alvarez and Lucas (2004) prove the existence of equilibrium and derive the conditions for its uniqueness for a particular version of the Eaton-Kortum model.

[9] Trade costs are reviewed in Anderson and van Wincoop (2004).

[10] Kortum (1997) and Eaton and Kortum (1999) provide microfoundations for this approach.

[11] The elasticity parameter gets absorbed into parameter γ that enters equations for prices and costs as a constant and has no effect on results. Since we never report the actual values of prices or costs, we can ignore it in this paper.

where T_{ij} and θ are technology parameters, and d_{nij} is the Samuelson's ('iceberg') transportation cost of delivering goods of industry j from country i to country n. Plugging (2) and (3) into (1), we get

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \prod_{m=1}^{J} \left[\sum_{n=1}^{N} T_{nm} \left(d_{inm} c_{nm} \right)^{-\theta} \right]^{-\frac{\eta_{jm}\left(1-\alpha_j-\beta_j\right)}{\theta}} . \tag{4}$$

Parameter T represents industry-level productivity and, therefore, determines comparative advantage across industries. Country n has a comparative advantage in industry j if $T_{nj}/T_{nm} > T_{ij}/T_{im}$.[12] Parameter θ determines the strength of product-level comparative advantage. Within industries, lower value of θ means more dispersion of productivities among producers, leading to stronger forces of intra-industry comparative advantage. Parameter d_{nij} measures transport costs. It represents the amount of good j that needs to be sent from country i so that 1 unit of this good arrives to country n. Free trade means that $d = 1$ while trade barriers result in $d > 1$.

Eaton and Kortum (2002) also derive the volume of trade between countries given technology parameters, distance, costs and prices. Adding industry dimension to their import share equation, it becomes

$$\pi_{nij} \equiv \frac{X_{nij}}{X_{nj}} = T_{ij} \left(\frac{d_{nij} c_{ij}}{p_{nj}} \right)^{-\theta} , \tag{5}$$

where X_{nij} is the spending of country n on industry j goods produced in country i, X_{nj} is the total spending in country n on industry j goods, and π_{nij} is country i's share in the amount that country n spends on goods of industry j.

Industry output Q_{ij} is determined as follows. We have

$$Q_{ij} = \sum_{n=1}^{N} X_{nij} = \sum_{n=1}^{N} \pi_{nij} X_{nj} = \sum_{n=1}^{N} \pi_{nij} \left(Z_{nj} + Y_{nj} \right) , \tag{6}$$

where Z_{nj} are Y_{nj} are amounts spent by country n on industry j's intermediate and final goods, respectively. Spending on final goods Y_{nj} consists of consumption C_{nj} and investment B_{nj}.

Total spending on intermediate goods made by industry j, Z_{nj} is

$$\sum_m Z_{nmj} = \sum_m p_{nj} M_{nmj} = \sum_m \eta_{mj} \rho_{nm} M_{nm} = \sum_m \frac{\eta_{mj} \left(1 - \alpha_m - \beta_m\right)}{\beta_m} w_n L_{nm},$$

where Z_{nmj} is the amount spent by industry m on intermediate goods from industry j, and M is the quantity of intermediate goods.[13]

Consumer preferences are two-tier: Cobb-Douglas across industries and, as we mentioned, CES across goods within each industry. Because preferences across industries are Cobb-Douglas, each country spends a constant proportion of its total consumption on goods from each industry. We also assume a fixed savings rate, so that consumption spending on each industry is also a constant

[12] Parameter T is not the same as total factor productivity (TFP). Parameter T determines the mean of the Fréchet distribution and is exogenous in our model. TFP, on the other hand, is endogenous. An analytic relationship between T and TFP is impossible to derive, but we can calculate TFPs given the parameters of the model (see Appendix D).

[13] Appendix A explains this part in greater detail.

proportion of country income: $C_{nj} = \psi_{nj} VA_n$, where VA_n is total income (GDP) in country n.[14] We allow for different tastes across countries by letting ψ_{nj} be country-specific.

We measure capital K in real units. Capital can be freely and instantaneously moved across industries within a country, subject to the constraint $\sum_j K_{ij} = K_i$. The country capital stock K_i is fixed. Rental rate r_i is determined by the market. In Appendix C, we develop two extensions of the model that endogenize capital stock K_i.

The capital good is a composite, made up of goods from all industries. We assume that it is a Cobb-Douglas combination. We also assume, for simplicity, that industry shares in this composite good are the same regardless of where the capital is used.[15] The price of the capital good in country i is then

$$p_i^k = \prod_m p_{im}^{\eta_m^I}, \tag{7}$$

where η_m^I is the fixed share of industry m's goods in the composite capital good.[16]

Total investment spending in country i is given by its income and exogenous savings rate s_i: $B_i = s_i VA_i$. The portion of total investment spending that goes toward goods from industry j is $B_{ij} = \eta_j^I B_i$. Plugging the expressions for intermediate, consumption, and investment spending into (6), we obtain the output equation:

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} \left(\left(\sum_{m=1}^{J} \frac{\eta_{mj} (1 - \alpha_m - \beta_m)}{\beta_m} w_n L_{nm} \right) + \eta_j^I s_n VA_n + \psi_{nj} VA_n \right). \tag{8}$$

Industry factor employments are given by

$$K_{ij} = \frac{\alpha_j Q_{ij}}{r_i} \text{ and } L_{ij} = \frac{\beta_j Q_{ij}}{w_i}. \tag{9}$$

Factor markets clear:

$$\sum_{j=1}^{J} K_{ij} = K_i \text{ and } \sum_{j=1}^{J} L_{ij} = L_i, \tag{10}$$

where L_i and K_i are given.[17]

Due to data limitations, we only model manufacturing industries. We normalize the price index in nonmanufacturing sector to 1 and take nonmanufacturing income as given.[18] We treat purchases by the nonmanufacturing sector of manufacturing intermediates as final consumption.

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[14] Consumption C includes private consumption and government consumption.

[15] This assumption is supported by data, which shows that η_m^I is very similar across industries and countries.

[16] Superscript 'I' stands for 'investment'.

[17] In Appendix C, we extend the model to incorporate endogenous capital accumulation and international investment. These extensions link international trade with economic growth and create a bridge between our model and open-economy macro models. An important feature of these extensions is the ability to determine the price of the capital good separately from the prices of consumption goods. This allows us to make the distinction between capital stock and financial capital that is used to buy the capital stock. The amount of savings and the quantity of investment are linked by the price of capital.

[18] This means that other sectors are not influenced by manufacturing and vice versa. For example, a technological improvement in the Machinery industry has no effect on costs of production or income in nonmanufacturing sectors (e.g. agriculture, mining, services).

Country income VA_i is the sum of manufacturing income VA_i^M and nonmanufacturing income VA_i^O:

$$VA_i = VA_i^M + VA_i^O = w_i L_i + r_i K_i + VA_i^O. \tag{11}$$

Factor stocks K_i and L_i are specific to manufacturing.

2.2 Solving the model

The model is given by equations (3)-(5) and (7)-(11). Model parameters are α_j, β_j, η_{jm}, η_m^I, θ, ψ_{nj}, s_n, d_{nij}, T_{nj}, L_n, K_n, and VA_n^O. We solve for all other variables including all prices, industry factor employments, and trade.

We measure the extent of intra-industry trade by the Grubel-Lloyd index:

$$IIT_{nij} = \frac{2 \min \left(Trade_{nij}, Trade_{inj}\right)}{Trade_{nij} + Trade_{inj}}.$$

This index varies between 0 (no intra-industry trade) to 1 (all intra-industry trade).

3 Parametrizing and evaluating the model

Model parameters are obtained using three methods. Some parameters are taken from data or literature. Transport costs d_{nij} are estimated from a gravity equation. The rest of the parameters are obtained by fitting a subset of model equations to domestic data. Because these equations rely solely on domestic data, we can examine model performance by comparing trade flows predicted by the model to the actual ones. We do this in Section 3.4.

We use data on 8 two-digit manufacturing industries (listed in Table 2b) in 19 OECD countries (listed in Table 2a). We use data from 1989 because this is the year for which most observations are available. Data sources are described in Appendix B.

Section 3.1 describes parameters which are taken from data or literature. Estimation of transport costs is discussed in Section 3.2. Methodology and results for fitted parameters are presented in Section 3.3. For convenience, we summarize parameters in Table 1.

3.1 Parameters taken from data and literature

Factor and intermediate input shares are shown in Table 3. Intermediate inputs constitute by far the largest part of output, with shares around 0.7-0.8. Labor shares are around 0.1-0.2 and capital shares are between 0.05-0.1.

To present factor shares in a more familiar form, the last column of Table 3 shows implicit capital shares in value added, calculated as $\alpha_j / \left(\alpha_j + \beta_j\right)$. These shares vary from 0.22 to 0.415 across industries. Textile and Wood are the two most labor-intensive industries while Chemicals and Metals are the two most capital-intensive industries.

Industry shares for intermediate and investment goods are shown in Table 4. Uses of own intermediate goods are in bold. Own intermediate goods always constitute the largest share of all manufacturing inputs, but never make up more than a half of all inputs. Share of manufacturing inputs varies between 0.27 in the Food industry to 0.96 in the Chemicals industry. Food, Nonmetals,

Name	How obtained
α_j	production data and Shikher (2004a)
β_j	production data
η_{im}	input-output tables
η^I_m	input-output tables
θ	8.28, 3.6, 13 (see text)
d_{nij}	estimated, trade and output data
ψ_{nj}	fitted, output and spending data
s_i	fitted, output and spending data
T_{ij}	fitted, output and spending data
L_n	fitted, output and spending data
$K_{n,0}$	fitted, output and spending data
VA^O_n	fitted, output and spending data

Table 1: List of model parameters

and Wood industries have the largest shares of nonmanufacturing inputs, mostly likely agricultural and natural resource products.

The last column of Table 4 shows industry shares in the capital good. Output of the Machinery industry constitutes by far the largest share in the capital good, 66%. Output of the nonmanufacturing sector, specifically the construction industry, constitutes 31% of the capital good.

We take the value of θ from Eaton and Kortum (2002), where it is estimated to be 8.28 using trade and price data. To make sure that our results are not sensitive to this choice, we also perform our investigations using two additional values of θ: 3.6 and 13. The lower value is the result of Eaton and Kortum's (2002) alternative estimation procedure that uses data on national R&D stocks, education, and wages. The upper value is explained below.

In the next section, we will show that the value of θ affects the estimates of transport costs, as can be seen in equation (16). Higher value of θ results in lower estimates of transport costs.[19] While $\theta = 8.28$ implies that the average transport cost between countries is 2.27, $\theta = 3.6$ implies an improbably large value of 6.6, which is why Eaton and Kortum (2002) themselves prefer the 8.28 estimate.

Anderson and van Wincoop (2004) estimate the average international transport cost between OECD countries to be around 1.7 (excluding local distribution margins, see pp. 692-693). The value of θ that implies this average transport cost is 13, which we make our third estimate of θ. We believe that the range 3.6-13 represents the range of plausible values of θ. As it turns out, the choice of θ (within this range) has very little effect on the results presented in this paper. Choosing one value of θ over the other changes the results by at most 2 percentage points (usually much less than that), and does not affect our conclusions. Therefore, we only present the results for $\theta = 8.28$.

[19] Transport costs cannot be estimated separately from θ using only trade and production data. Additional information, such as output prices, is required.

3.2 Transport costs

We follow EK's methodology for estimating transport costs. From (5):

$$\frac{\pi_{nij}}{\pi_{nnj}} = \frac{X_{nij}}{X_{nnj}} = \frac{T_{ij}}{T_{nj}} d_{nij}^{-\theta} \left(\frac{c_{ij}}{c_{nj}} \right)^{-\theta}. \tag{12}$$

We define

$$S_{ij} \equiv T_{ij} c_{ij}^{-\theta}, \tag{13}$$

a measure of international competitiveness of industry j of country i. Taking logs of both sides of (12) and using the definition of S_{ij} we get a gravity-like equation:

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta \log d_{nij} + \log S_{ij} - \log S_{nj}. \tag{14}$$

Following EK, we proxy transport costs by

$$\log d_{nij} = d_{kj}^{phys} + b_j + l_j + f_j + m_{nj} + \delta_{nij}, \tag{15}$$

where d_{kj}^{phys} $(k = 1, ..., 6)$ is the effect of physical distance lying in the kth interval, b is the effect of common border, l is the effect of common language, f is the effect of belonging to the same free trade area, m_n is the overall destination effect, and δ_{ni} is the sum of transport costs that are due to all other factors. Note that all transport costs are industry-specific. Also note that by definition $\log d_{iij} \equiv 0$.

Combining (14) and (15), we obtain the estimating equation:

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta d_{kj}^{phys} - \theta b_j - \theta l_j - \theta f_j + D_{ij}^{exp} + D_{nj}^{imp} - \theta \delta_{nij}, \tag{16}$$

where $D_{ij}^{exp} = \log S_{ij}$ is the exporter dummy and $D_{nj}^{imp} = -\theta m_{nj} - \log S_{nj}$ is the importer dummy.[20] Destination-industry specific import barriers are calculated as $m_{nj} = -(1/\theta) \left(D_{nj}^{exp} + D_{nj}^{imp} \right)$.

The average (across country pairs and industries) estimated transport cost is 2.27 (if $\theta = 8.28$). This transport cost includes all costs necessary to move goods between countries, such as freight, insurance, tariffs, non-tariff barriers (NTBs), translation of documents, and theft in transit. The minimum transport cost in any industry is around 1 and the maximum is 6.62. Average transport costs for each industry are listed in Table 5. Machinery and Textile products are cheapest to move between countries while Wood and Food products are the most expensive.

We present the estimated import barriers m_n in Table 6. Import barriers in each industry are measured relative to the United States, so that comparisons across industries are not possible. Total transport costs d_{nij}, on the other hand, are measured in absolute terms.

Rankings of countries according to their import barriers in each industry are shown in Table 7. The United States is the most open country in all industries except the Textile industry. Turkey and Greece are the most closed countries. The last line on Table 6 shows the average import barrier of all countries other than the U.S. We can see that relative to other countries, U.S. tends to be less open in Textile and Metals industries and more open in Wood, Food, and Machinery industries.

[20] Helpman, Melitz and Rubinstein (2004) derive a gravity equation from a model with monopolistic competition and fixed trade costs. Their formulation allows for zero trade between countries.

3.3 Technology and other fitted parameters

We obtain the technology parameters T_{ij} by fitting a subset of our model, together with a long-run equilibrium condition, to data. We use the cost equation (4), reproduced below for convenience:

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \prod_{m=1}^{J} \left[\sum_{n=1}^{N} T_{nm} \left(d_{inm} c_{nm} \right)^{-\theta} \right]^{-\frac{\eta_{jm}\left(1-\alpha_j-\beta_j\right)}{\theta}}. \tag{17}$$

We also use a simplified version of the output equation (8):

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} X_{nj}, \tag{18}$$

where import shares π_{nij} are calculated using equations (5) and (3).

In addition, we assume a long-run equilibrium condition that the rates of return normalized by prices of capital are equalized across countries:

$$r_i = r^w p_i^k, \tag{19}$$

where r^w is the world interest rate, and capital good prices p_i^k are calculated using equations (7) and (3). This equilibrium condition is only assumed for the purpose of estimating the technology parameters. We do not use it when performing counterfactual simulations in Sections 4 and 5.

To solve equations (17)-(19) we use data on wages w_i, output Q_{ij}, and spending X_{nj}, and set the world interest rate r^w to 20%.[21] We also use the transport costs d_{nij} estimated in the previous section. We solve for the technology parameters T_{nm}, rates of return r_i, and costs c_{ij}.[22]

With values for T_{nm}, r_i, and c_{ij} in hand, we calculate the remaining parameters: factor stocks L_n and K_n, nonmanufacturing income VA_n^O, savings rates s_n, and demand shares ψ_{nj}. First, we calculate industry factor employments by plugging in the estimated rates of return r_n and data on output and wages into equation (9). We then calculate total factor stocks as the sum of industry factor employments. Income in nonmanufacturing VA_i^O is calculated as the difference between total income VA_i, taken from data, and manufacturing income $VA_i^M = r_i K_i + w_i L_i$.

In order to calculate savings rates we assume that the economy is in a steady state, so that total savings are just enough to replenish the depreciated capital stock:

$$s_i = \frac{\delta p_i^k K_i}{VA_i}. \tag{20}$$

In this expression, δ is the depreciation rate, set to 10%, and VA_i is the actual GDP.[23]

The taste parameter ψ_{ij} is the proportion of total country income spent on consumption goods from industry j: $\psi_{ij} = C_{ij}/VA_i$. As we mentioned before, we allow for heterogeneity of

[21] The results presented in this paper are insensitive to the value of the world interest rate.

[22] Our procedure for finding T's is different from Eaton and Kortum's (2002). They calculate technology parameters from the estimated competitiveness measures (13) and data on wages. We cannot use a similar procedure because data on rates of return is not available. Instead, we use a subset of our model to simultaneously solve for the rates of return and technology parameters. Note that competitiveness measures S_{ij} that are calculated using fitted values of T_{ij} and c_{ij} may be different from those that are estimated in the gravity equation.

[23] We assume that net foreign investment is zero.

tastes across countries by letting ψ be country-specific. The consumption of industry j goods in country i is calculated as $C_{ij} = X_{ij} - Z_{ij} - B_{ij}$. In that expression, the total spending X_{ij} is taken from data. The amount spent on intermediate goods from industry j is calculated as $Z_{ij} = \sum_{m=1}^{J} \eta_{mj} (1 - \alpha_m - \beta_m) Q_{im}$, where industry output Q_{im} is taken from data. Finally, the amount spent on investment goods from industry j is calculated as $B_{ij} = \eta_j^I s_i VA_i$.

We now have values for parameters T_{ij}, L_n, K_n, VA_n^O, s_n, and ψ_{nj}. In order to obtain these values, we used transport costs d_{nij}, estimated in the previous section, and data on output Q_{ij}, spending X_{ij}, wages w_i, total income VA_i, and Cobb-Douglas shares α_j, β_j, η_{im}, and η_m^I. In addition, we needed to set values for the long-run world interest rate r^w and depreciation rate δ. Note that we fitted the model using only domestic data. This allows us to evaluate our model in Section 3.4 by comparing trade flows predicted by the model to actual.

Estimated industry technology parameters relative to the United States are shown in Table 8. Rankings of countries according to their technology parameters in each industry are shown in Table 9. United States has the highest technology parameter in Food, Wood, Paper, and Chemicals industries. Italy has the highest technology parameter in Textile industry while Japan has the highest technology parameter in Nonmetals, Metals, and Machinery. Developing countries are generally at the bottom of the rankings.

Capital-labor ratios in manufacturing, relative to the United States', are shown in the last column of Table 8. Rankings are shown in the last column of Table 9. U.S., Japan, France, and Germany have the highest capital-labor ratios, while Turkey, Mexico, Portugal, and Greece have the lowest.

Our methodology for obtaining technology parameters also allows us to find the technology parameter of the nontraded sector. We do not do it in this paper, but describe the procedure in Appendix E.

3.4 Evaluating the model

In Section 3.2, we estimated transport costs using a gravity equation. Then, in Section 3.3, we obtained technology and other parameters by fitting a subset of the model to domestic data. In this section, we evaluate the model using two approaches. First, we check how well the model can predict trade flows and the prevalence of intra-industry trade. Second, we evaluate the model by using it to perform counterfactual simulations and comparing predictions with results from other empirical studies.

We start by examining how well the model can predict trade flows.[24] In order to summarize the fit of the 19*18*8=2,736 trade flows generated by the model, we use the ratio of error sum of squares to the actual sum of squares. This ratio is equal to 0.03.

We also look at percent deviations of predicted from actual trade flows. The average percent deviation is 7.05%. Table 10 shows the average prediction errors by industry. The average errors vary between 3.59% in the Food industry and 11.17% in the Machinery industry.

An important feature of our model is the presence of both inter-industry and intra-industry trade. Therefore, an important test for this model is whether it can correctly predict the prevalence intra-industry trade. To measure intra-industry trade we use the Grubel-Lloyd (GL) IIT index. In each industry, we calculate the GL index for each pair of countries. Averaging all bilateral GL

[24] Trade flows are calculated as $X_{nij} = \pi_{nij} X_{nj}$.

indices in an industry, we arrive at the industry GL index. Averaging all bilateral GL indices across all industries we arrive at the world GL index.

The predicted and actual industry and world GL indices are shown in Table 11. We can see that the model predicts the size of intra-industry trade quite accurately. The predicted world GL index is within 0.06 points of the actual, while predicted industry-level GL indices are within 0.03-0.1 points of the actual.

How well does the model predict trade flows and intra-industry trade for each country? Table 12 shows that the model does about as well for individual countries as it does for individual industries. Importantly, it shows that the model predicts trade for poorer countries, such as Turkey, Mexico, and Greece, as well as it does for richer countries.

The second approach to evaluating the model involves conducting a counterfactual experiment and comparing the results with those of another empirical study. In Section 5, we perform an experiment in which the capital-labor ratio in a country is increased and the effect on specialization, measured by industry shares, is recorded. We then compare our results to the results obtained by applying regression methodology of Harrigan (1997) to our dataset. The effects predicted by our model are close to those estimated by regression, providing further support for the model.

4 Accounting for international trade

Trade in our model is determined by factor endowments, industry- and product-level comparative advantage, geography, and tastes. Thus, our model combines the determinants of trade found influential in previous literature.

We have the ability to find out how much each of these determinants of trade contributes to the volume of trade and size of intra-industry trade. This exercise is similar to the growth accounting exercise, where structure is imposed on data and the contribution of each component is calculated.

To find the contribution of each determinant of trade, we remove them one-by-one and note the effects on the volume of trade and size of intra-industry trade, measured by the GL index. Later in this section, we will consider how much the pattern of trade, as measured by net exports, changes when individual determinants of trade are removed.

As explained in Section 2.2, the model is given by equations (3)-(5) and (7)-(11). We take capital stock, technology, and other parameters and solve for all prices, including wages and rates of return, as well as trade and industry factor employments.

To remove factor endowment differences, we set capital-labor ratios equal in all countries. To remove comparative advantage on the industry level, we set relative technologies to be equal in all countries. In other words, we set $T_{nj}^{new} = \tau_n T_{us,j}$, where τ_n is an average of current relative technology parameters. To remove comparative advantage on the product level, we increase θ.[25]

We find that the volume of trade depends little on the strength of industry-level technological and factor endowment advantages. Shutting down industry-level comparative advantage causes a 5% reduction in the volume of trade, shutting down factor endowment differences has virtually no effect on the volume of trade, and shutting down both causes a 4% decrease in the volume of trade. We find that lower volume of inter-industry trade is compensated by higher volume of

[25] In practice, we can increase θ twelve times, to 100. A numerical solution is not obtainable for higher values. Increasing θ also affects the mean of the Fréchet distribution, in turn affecting the industry-level comparative advantage. To compensate, we adjust T_{nj}'s so that the means remain constant, resulting in a much greater 'spread' of T_{nj}'s. However, this adjustment has virtually no effect on the results.

intra-industry trade. Removing taste differences by setting equal taste parameters in all countries actually increases the volume of trade by 6%.

On the other hand, the volume of trade is very sensitive to the strength of the product-level comparative advantage. Increasing θ to 100 reduces the volume of trade to about 7% of its current level. Both inter-industry and intra-industry portions of trade decline, but the remaining trade is all inter-industry (world average GL index is 0.03).

Countries become much more self-sufficient, and trade virtually disappears in some industries, such as Food. The least reduction of trade occurs in the Machinery and Textile industries, likely because the strength of the industry-level comparative advantage is greater in those industries. But even in the Machinery industry, the remaining trade is only 10% of its current level.[26]

These results coincide with what we know about export behavior of individual producers (see Section 2 for references). We know that trade is driven by outstanding producers. In any country, the average producer does not export. Only producers that are significantly more efficient than the average are able to overcome the trade costs and be competitive in foreign markets. By increasing θ, we make all producers mediocre. Therefore, given the current levels of trade barriers, trade virtually disappears.

With θ being very high, there are virtually no differences of productivity between firms within an industry. As the result, intra-industry trade disappears. Intra-industry trade, however, comprises less than a half (45%) of total trade in our dataset, and industry-level comparative advantages still remain. Why then does the total volume of trade fall 93%?

The reason is that inter-industry trade does not increase to compensate for lower intra-industry trade, as was the case with higher intra-industry trade compensating for lower inter-industry trade. In fact, the volume of inter-industry trade falls significantly as well, making the total volume of trade extremely low. These results indicate that extraordinary producers drive inter-industry trade as well, and that industry-level comparative advantages contribute little to their success.

Table 13a summarizes the accounting for the volume of trade. Within-industry heterogeneity (product-level comparative advantage) accounts for 93% of the volume of trade. Different relative productivities across industries, which create industry-level comparative advantage, account for 6% of the volume of trade. Differences of factor endowments across countries have virtually no effect on trade (they decrease trade by 1.3%). Differences of tastes across countries decrease trade by 6%.

Our results also show that as countries become more similar to each other in terms of factor endowments and tastes, they begin to trade more, not less. The size of intra-industry trade increases, while the size of inter-industry trade declines. The total volume of trade between countries, however, becomes higher.[27]

With regard to sizes of inter- and intra-industry trade, removing product-level heterogeneity, as we already noted, removes all intra-industry trade and decreases GL index to 0.03. To account for inter-industry trade, we first shut down factor endowment differences, which increases the GL index by 2.5%. Shutting down industry-level comparative advantage increases inter-industry trade by 13%. Shutting both down increases GL index 15%, from 0.46 to 0.53. The effects of

[26] Even reducing trade barriers at this point does very little to increase the volume of trade. Starting with $\theta = 100$, a moderate reduction of trade barriers leads to only a small increase of trade volume. Setting distance effects 20% closer to one ($d = 1$ mean free trade) brings the volume of trade only 4% closer to its current level. The GL index remains at 0.03 during this experiment. Numerical solutions for lower trade barriers in this case could not obtained.

[27] Removing absolute advantages by setting $T_{ij} = \overline{T}_i$ increases the world trade by about 20%. Again, as countries become more similar, they trade more.

the two sources of industry-level advantage are approximately additive, i.e. removal of one has approximately the same effect regardless of whether the other one has been removed.

To account for the remainder of inter-industry trade, we have to remember that there are two other industry-level determinants of trade: tastes and geography. Removing taste differences across countries raises the GL index by 8%, from 0.53 to 0.57.

Geography works through intermediate goods and industry linkages. In the presence of transport costs, being close to countries that are productive is an advantage because of access to cheaper intermediate goods. Since this advantage depends on the presence of trade barriers, we can turn it off by removing all trade barriers, i.e. setting all distance parameters to one. Location will then have no effect, since prices will be the same in all countries. Setting all distance parameters to one increases the GL index from 0.57 to 0.96.

Table 13b summarizes the accounting for inter- and intra-industry trade. The current value of the GL index is 0.46. By changing model parameters, we are able to vary the GL index between 0.03 and 0.96.

We now turn our attention to the pattern of trade, represented by net exports. We find that removing industry-level comparative advantage has dramatic effects on the pattern of trade. Nearly a half (75 out of 152) of observed net exports change signs, meaning that trade flows reverse. Tables 14a and 14b reveal the changes of exports and imports that occur when industry-level comparative advantage is removed. Removing factor endowment differences also has an effect on the pattern of trade, albeit a much smaller one (trade flows reverse in 14 out of 152 cases). The effect of shutting down product-level comparative advantage on the pattern of trade seems to be moderate. Trade becomes mostly one-way and many trade flows shut down, but most of the remaining trade flows follow the original pattern.

The results of this section demonstrate the separate roles of key determinants of trade. Industry-level comparative advantage and factor endowment differences are mostly responsible for the pattern of trade. Within-industry heterogeneity drives the volume of trade. In addition, industry-level comparative advantage and factor endowment differences account for only a small portion of inter-industry trade. Geography-dependent sources of advantage account for most of it.[28]

We also conclude that factor endowment differences have a weaker effect on the volume and pattern of trade than do technological differences. Factor endowment differences have a negligible effect on the volume of trade and only a small effect on the pattern of trade. Of course, these results are obtained using only manufacturing sector data. They may change when other factors and other sectors are included in the model. For example, including natural resource endowments and mining and agriculture sectors may affect the results.

Similarly, our conclusions with respect to the relative importance of product-level and industry-level comparative advantages are based on a model with a low level of disaggregation. The relative importance of industry-level comparative advantage would probably increase if we were to use a more disaggregated specification.

5 Technology, factor endowments, and specialization

Specialization is one of the key topics in international trade. It has been addressed in numerous works. Most of the previous studies analyzed how factor endowments and, to a lesser extent, tech-

[28] We want to note that there is nothing in the model to make these results obvious. For example, there is nothing to indicate apriori that industry-level comparative advantage would have such a small effect on the volume of trade.

nology affect specialization.[29] In this section, we use our model to address the same question and compare our results with results of previous studies. Similarity of results provides further validation of our model. Moreover, compared with previous studies, we are able to provide additional insights into the effects of technology and factor endowments on specialization.

A recent empirical study that combines technological and factor endowment explanations of specialization is Harrigan (1997). Harrigan estimates the effects of technology, measured by industry TFP, and factor endowments on specialization, measured by industry shares. Harrigan uses a reduced-form estimating equation derived from the translog revenue function. Shikher (2004b) modifies the methodology of Harrigan by accounting for variable capital utilization when calculating total factor productivity.

Here, we have an opportunity to use a structural model to address the same question. We want to determine the effect of capital stock and technology on specialization. Our model shares many features with Harrigan's, such as constant returns to scale and factors that are mobile across industries and fixed for a country. Our model has two factors, capital and labor, which allows us to study the effect of capital-labor ratio on specialization.

Since we have industry- and country-specific measures of technology, we can also study the effect of technology on specialization. Of course, our measure of technology is different from Harrigan's. He uses TFP, which is exogenous in his framework, whereas we use the technology parameter T (TFP is endogenous in our model).

To find the effect of capital stock on specialization, we will increase manufacturing capital stock in one country, holding capital stocks of other countries constant, and simulate the model. After each simulation, we will note the change in country n's specialization brought about by the increase of country n's capital stock. We will measure specialization by industry shares, just as Harrigan did. We will repeat this for every country in our sample, which means that we will run 19 simulations.

We will use a similar procedure to measure the effect of technology. Holding all other technology parameters constant, we will raise the technology parameter in industry j of country n and measure the resulting change in specialization in country n. We will repeat this for each industry and each country in the sample (19*8=152 simulations total).

The coefficients estimated in the framework of Harrigan (1997) are semielasticities of industry shares with respect to capital. To obtain a comparable number, we will divide changes of industry shares by the percent change of capital that we simulated. We then average the result across countries:

$$\alpha_j = \frac{1}{N}\sum_n \alpha_{nj} = \frac{1}{N}\sum_n \frac{100\left(S_{nj1} - S_{nj0}\right)}{\log\left(K_{n1}/K_{n0}\right)},$$

where $S_{nj} = VA_{nj}/VA_n$ is the share of industry j in GDP. Note that we calculate coefficients by subtracting the initial values for the same country, so they are comparable to within-country estimates of Harrigan.[30]

The simulated values of α_j are presented on the first row of Table 15. The coefficient of -1.173 in the Food industry means that if total capital stock increases by 10%, the share of the Food

[29] Good reviews of the latest works in this area are in Leamer and Levinsohn (1995) and Harrigan (2003).

[30] We simulate increases of 10, 20, 30, and 40% with no noticeable differences in the results. We report the averages over these experiments. Elasticities, which we report in addition to semielasticities, are measured as $\varepsilon_n = \frac{1}{N}\sum_n \frac{\log\left(S_{nj1}/S_{nj0}\right)}{\log\left(K_{n1}/K_{n0}\right)}$.

industry will decrease by 0.1173 percentage points. The regression results, shown on the second row of Table 15, are obtained by using the methodology of Shikher (2004b) We use data for our set of countries (shown in Table 2a) and years 1975-1995 (which places our simulation year 1989 approximately in the middle of this time period).[31]

The coefficients obtained from simulation and regression are plotted against each other in Figure 1, the straight line showing a unit slope. The signs of the coefficients match for all industries, and the correlation coefficient is 0.68. Given that they are obtained using such different methodologies, it is remarkable that the signs and magnitudes of coefficients are so similar.[32] The similarity provides cross-validation of the regression and simulation approaches.

In addition to providing a way to evaluate our model, the exercise of this section provides us with an additional insight into the effects of capital stock on specialization. When using simulation rather then regression to obtain the coefficients, we have the advantage of being able to look at the coefficients for each country individually. When looking at country-specific coefficients for each industry, shown in Table 16 and summarized in Table 16a, we see that there is a good deal of variability in the effect of capital stock across countries.

Only in two industries, Wood and Metals, the signs of the coefficients are the same for all countries. In Paper, Nonmetals, and Machinery industries, half of coefficients is positive, while the other half is negative. The magnitude of the effects can be very different as well, even in industries where the direction of the effect is the same in all countries. For example, the effect of higher capital stock on the share of the Metals industry is three times higher in Norway than it is in Japan.

This variability limits the usefulness of average coefficients. While the average effect of capital stock on share of the Food industry is -1.2, it varies between -2.1 and 0.2 for individual countries. In the Machinery industry, the average effect is 0.1, while for individual countries it varies between -1.5 and 1.3. It does not seem that we can pin down the effect of capital stock on specialization that would be applicable to all, or even most, countries. The size and, for many industries, direction of the effect are country-specific and probably depend on other factors, such as technology and geography.[33,34]

Since it is difficult to get an intuitive feel for semielasticities, we also report elasticities of industry shares with respect to capital in Table 17. To gauge the effects of technology on specialization, we will focus exclusively on elasticities. Remember that our measure of industry technology is different from Harrigan's. Therefore, magnitudes of technology effects on specialization are not comparable. However, the effects should be similar qualitatively.

Share elasticities with respect to technology are presented in Table 18. Elasticities with respect to own technology are bolded for convenience. All of them are positive, while all cross-industry

[31] Since we increase manufacturing capital stock in simulations, we do the same in regression, using manufacturing capital-labor ratios on the right-hand side.

[32] The Metals and Food industries are the biggest outliers, with simulation coefficients being greater in absolute value than the regression coefficients.

[33] This variability would show up as a low R^2 in a regression. In Harrigan's methodology, most of the variation of the shares is explained by the fixed effects, so it is difficult to tell how well the model would explain the data in the absence of the fixed effects.

[34] The correlation between average (across countries) elasticities and capital shares is 0.55 for capital share in output and 0.59 for capital share in value added. This correlation can be interpreted as evidence of the Rybczynski effect (see Ethier (1982a); we can not refer to the Rybczynski theorem since goods prices are not held constant in our model). However, the relationship between capital share and the effect of capital stock on specialization is far from clear-cut. For example, Food industry is capital-intensive, but shrinks when capital stock increases. The opposite is true for the Machinery industry.

elasticities are negative. These results echo the estimation results of Harrigan and Shikher, where all own-TFP effects were positive, while most of cross-industry effects were negative.

Share elasticities with respect to own technology parameters vary between 0.214 for the Food industry and 0.691 for the Metals industry. Most cross-industry elasticities are an order of magnitude less than own-industry elasticities. Machinery industry, however, is an exception. Its technology parameter has a strong negative effect on the shares of other industries, with the largest effect on the Textile industry. A ten-percent increase of the Machinery industry technology parameter in an average country would result in Machinery share increasing by 3.95% and Textile share decreasing by 3.31%.

The magnitudes and signs of elasticities are quite similar across countries (see Tables 18a-18d). Own-industry elasticities are always positive. With few exceptions, cross-industry elasticities are negative. Thus, the effect of technology parameters on specialization is much more invariable across countries than the effect of capital stock.

6 Conclusion

We develop a new computable model of trade. The model is compact and does not require the Armington assumption to explain intra-industry trade, instead relying on within-industry heterogeneity of producers. It can be used to study both the volume and the pattern of trade, as well as specialization. The model incorporates all the major determinants of trade: technology, factor endowments, tastes, and trade costs.

We parametrize the model and evaluate its fit. We find that the model accurately predicts the direction and magnitude of international trade flows. We then use the model to perform several investigations.

In the first investigation, we use the model to analyze the effects of comparative advantage, factor endowments, tastes, geography, and within-industry heterogeneity on the volume and composition of trade. Our results show the separate roles of these key determinants of trade. We find that the volume of trade is determined mostly by within-industry heterogeneity, inter-industry trade is governed largely by geographic advantages, while the pattern of trade is affected the most by industry-level comparative advantage.

The volume of trade depends little on the strength of industry-level technological and factor endowment advantages. When these determinants of trade are removed, lower inter-industry trade is compensated by higher intra-industry trade. On the other hand, the volume of trade is very sensitive to the strength of the product-level comparative advantage. Our results suggest that outstanding producers in each industry are key to both intra-industry and inter-industry trades. Industry-level comparative advantages contribute little to their success.

Our results also show that as countries become more similar, they trade more with each other, not less. As differences between countries' factor endowments and tastes narrow, they engage in more intra-industry trade and less inter-industry trade. Meanwhile, the total volume of trade between them increases.

Taking a look at the pattern of trade, we find that eliminating industry-level comparative advantages has a dramatic effect, causing nearly a half of all trade flows to reverse direction. Eliminating factor endowment differences has a much smaller effect, and shutting down product-level comparative advantage seems to have a moderate effect.

In the second investigation, we study the effects of factor endowments and technology on specialization, a topic addressed in several recent empirical studies. We find that the average effects of capital stock on industry shares predicted by simulation are similar to those obtained by regression. This similarity provides support to our and regression methodologies.

Compared with previous studies, we are also able to provide additional insight into the effects of capital stock and technology on specialization. We find, for example, that the effect of capital stock on specialization varies significantly in sign and magnitude across countries. On the other hand, we find the effects of technology on specialization to be much more similar across countries. Higher technology in an industry always increases that industry's share and almost always decreases shares of other industries.

References

Alvarez, F. and Lucas, R. E. (2004). General equilibrium analysis of the Eaton-Kortum model of international trade, *Working Paper*.

Anderson, J. and van Wincoop, E. (2004). Trade costs, *Journal of Economic Literature* **42**(3): 691–751.

Armington, P. S. (1969). A theory of demand for products distinguished by place of production, *IMF Staff Papers* **16**(1): 159–78.

Aw, B. Y., Chung, S. and Roberts, M. J. (1998). Productivity and the decision to export: Evidence from Taiwan and South Korea, *NBER Working Paper No. 6558*.

Baxter, M. (1995). International trade and business cycles, *in* G. M. Grossman and K. Rogoff (eds), *Handbook of International Economics, Volume III*, Elsevier, chapter 35.

Bernard, A. B. and Jensen, B. J. (1995). Exporters, jobs, and wages in U.S. manufacturing: 1976-1987, *Brookings papers on economic activity: Microeconomics*.

Bernard, A. B. and Jensen, B. J. (1999). Exceptional exporter performance: Cause, effect, or both?, *Journal of International Economics* **47**.

Bernard, A., Eaton, J., Jensen, J. B. and Kortum, S. (2003). Plants and productivity in international trade, *American Economic Review* **93**(4).

Brown, D. K. (1987). Tariffs, the terms of trade, and national product differentiation, *Journal of Policy Modeling* **9**(3): 503–526.

Clerides, S., Lach, S. and Tybout, J. R. (1998). Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco, *Quarterly Journal of Economics* **67**.

Davis, D. R. (1995). Intra-industry trade: A Heckscher-Ohlin-Ricardo approach, *Journal of International Economics* **39**: 201–226.

Dixit, A. and Norman, V. (1980). *Theory of International Trade*, Cambridge University Press.

Eaton, J. and Kortum, S. (1999). International technology diffusion: Theory and measurement, *International Economic Review* **40**: 537–570.

Eaton, J. and Kortum, S. (2001a). Technology, trade, and growth: A unified framework, *European Economic Review* **45**: 742–755.

Eaton, J. and Kortum, S. (2001b). Trade in capital goods, *European Economic Review* **45**(7): 1195–1235.

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

Eaton, J. and Kortum, S. (2005). *Technology in the Global Economy: A Framework for Quantitative Analysis*, Forthcoming.

Eaton, J., Kortum, S. and Kramarz, F. (2004). An anatomy of international trade: Evidence from french firms, *NBER Working Paper No. 10344*.

Ethier, W. (1982a). The general role of factor intensity in the theorems of international trade, *Economics Letters* **10**: 337–342.

Ethier, W. J. (1982b). National and international returns to scale in the theory of international trade, *American Economic Review* **72**: 389–405.

Feenstra, R. C. (1997). World trade flows, 1970-1992, with production and tariff data, *NBER Working Paper 5910*.

Feenstra, R. C. (2000). World trade flows, 1980-1997, with production and tariff data, *UC David, Center for International Data website*.

Findlay, R. (1984). Growth and development in trade models, *in* R. W. Jones and P. B. Kenen (eds), *Handbook of International Economics, Volume I*, North-Holland, chapter 4.

Grossman, G. M. and Helpman, E. (1995). *Innovation and Growth in the Global Economy*, The MIT Press.

Harrigan, J. (1997). Technology, factor supplies, and international specialization: Estimating the neoclassical model, *The American Economic Review* **87**(4): 475–494.

Harrigan, J. (2003). Specialization and the volume of trade: Do the data obey the laws?, *in* K. Choi and J. Harrigan (eds), *The Handbook of International Trade*, Basil Blackwell. Previously published as FRBNY Staff Report No. 140.

Helpman, E. (1981). International trade in the presence of product differentiation, economies of scale, and monopolistic competition: A Chamberlin-Heckscher-Ohlin model, *Journal of International Economics* **11**: 305–340.

Helpman, E., Melitz, M. and Rubinstein, Y. (2004). Trading partners and trading volumes, *Working paper*.

Hirschman, A. O. (1958). *The Strategy of Economic Development*, Yale University Press, New Haven, CT.

Kortum, S. (1997). Research, patenting, and technological change, *Econometrica* **65**: 1389–1419.

Leamer, E. E. and Levinsohn, J. (1995). International trade theory: The evidence, *in* G. Grossman and K. Rogoff (eds), *Handbook of International Economics*, North-Holland, Amsterdam, pp. 1339–94.

McDaniel, C. A. and Balistreri, E. J. (2003). A review of Armington trade substitution elasticities, *Integration and trade* **7**(18): 161–73.

Panagariya, A. and Duttagupta, R. (2001). The "gains" from preferential trade liberalization in the CGE models: Where do they come from?, *in* S. Lahiri (ed.), *Regionalism and Globalization: Theory and Practice*, Routledge, chapter 3.

Shikher, S. (2004a). An improved measure of industry value added and factor shares: Description of a new dataset of the U.S. and Brazilian manufacturing industries, *Working Paper*.

Shikher, S. (2004b). Specialization in the neoclassical model allowing for variable capital utilization, *Working Paper*.

Smith, A. (1984). Capital theory and trade theory, *in* R. W. Jones and P. B. Kenen (eds), *Handbook of International Economics, Volume I*, North-Holland, chapter 6.

Stewart, W. A. (1999). World trade data set code book, 1970-1992.

Trefler, D. (1995). The case of the missing trade and other mysteries, *The American Economic Review* **85**(5): 1029–1046.

Appendix A Model notation

With many variables and indices, our notation may seem complicated. But in fact, it is easily understood in the context of a national input-output table. Therefore, to explain our notation, we consider a hypothetical input-output table of country n.

In an input-output table, rows represent sources of goods while columns represent uses of goods. In this section, m will represent the source industry (row) and j will represent the use industry (column). The table below shows our notation within a hypothetical input-output table that includes J industries.

At the intersection of each row m and column j is $Z_{njm} = p_{nm}M_{njm}$, spending by industry j on goods from industry m (note the similarity of this notation and our trade notation: goods move from right to left, in this case from m to j). M_{njm} is the quantity of good m used as input in industry j and p_{nm} is the price of industry m goods in country n.

In each row, $Z_{nm} = \sum_j Z_{njm}$ is total spending on intermediate goods made by industry m, Y_{nm} is spending on final goods made by industry m, and $X_{nm} = Y_{nm} + Z_{nm}$ is the total spending on industry m goods. Final spending Y_{nm} is the sum of consumption (private and government) and investment.[35] Total output of industry m in country n is $Q_{nm} = X_{nm} + EX_{nm} - IM_{nm}$, where EX are exports and IM are imports.

	Ind1($j=1$)	...	Ind$J$	Total	Y	EX	IM	Output
Ind1($m=1$)	$Z_{n21} = p_{n1}M_{n21}$			Z_{n1}	Y_{n1}	EX_{n1}	IM_{n1}	Q_{n1}
Ind2								
...								
Ind$J$								
Total	$\rho_{n2}M_{n2}$			Z_n	Y_n	EX_n	IM_n	Q_n
Salaries	w_nL_{n2}			w_nL_n				
Return	r_nK_{n2}			r_nK_n				
Income	VA_{n2}			VA_n				
Output	Q_{n2}			Q_n				

In each column j of the input-output table, $\rho_{nj}M_{nj} = \sum_m Z_{njm} = \sum_m p_{nm}M_{njm}$ is total amount spent by industry j on purchases of intermediate goods. In that expression, ρ_{nj} is the price of the composite intermediate input used in industry j, and M_{nj} is the quantity of this input. The share of industry m goods in all intermediate goods used by industry j is $\eta_{jm} = p_{nm}M_{njm}/\rho_{nj}M_{nj}$.

There are two factors, capital and labor. Therefore, factor payments in industry j consist of payments to labor, w_nL_{nj}, and capital, r_nK_{nj}. Income or value added is $VA_{nj} = w_nL_{nj} + r_nK_{nj}$. Output is equal to the sum of value added and intermediate inputs used: $Q_{nj} = VA_{nj} + \rho_{nj}M_{nj}$. Capital share in output of industry j is $\alpha_j = r_nK_{nj}/Q_{nj}$ and labor share is $\beta_j = w_nL_{nj}/Q_{nj}$. Share of intermediate goods is then $1 - \alpha_j - \beta_j = \rho_{nj}M_{nj}/Q_{nj}$. Note that each column and each row of the input-output table add up to total output. Of course, $Q_{nj} = Q_{nm}$ for $j = m$.

[35] If international movement of financial capital is allowed, final spending Y_{nm} includes spending by foreigners.

Appendix B Data sources

We collect data for 8 two-digit manufacturing industries (listed in Table 2b) in 19 OECD countries (listed in Table 2a).[36] We use data from 1989 because this is the year for which most observations are available.

Labor shares in output are from the UNIDO. We use average labor shares of the countries in our sample. Capital shares in output are obtained using ratios of capital to labor shares from the dataset described in Shikher (2004a). We multiply our labor shares by these ratios to obtain capital shares. We do not use value added data from UNIDO to obtain capital shares because that data are unreliable.[37]

Industry shares η_{jm} and η_m^I are obtained from the OECD input-output tables. OECD maintains separate tables for intermediate and investment goods. These tables exist only for some of the countries in our dataset and only for select years. We use input-output tables for Australia, Canada, France, Germany, Japan, U.K., and the U.S. for 1990.[38] Input-output tables for these countries result in very similar shares η_{jm}. We use average shares across these countries.

Input-output tables for investment goods have data on consumption of investment goods for each industry separately. However, we found that industry shares in investment goods are very similar across industries that use them. This means that the composition of capital goods used by different industries is similar. We assume that the capital good is the same in all industries and use the average, across industries, shares for investment goods.

Bilateral trade data needed to estimate equation (16) are from Feenstra (1997) and Feenstra (2000). Imports from home X_{iij} are calculated as output minus exports, and spending X_{ij} is calculated as output minus exports plus imports. Industry output and labor compensation are from the UNIDO's statistical database.

Distance measures used on the right-hand-side of equation (16) are obtained as follows. We use distance (in miles) between economic centers of countries from Stewart (1999). This distance is the great circle distance between the population weighted average of the latitude and longitude of major cities. Following EK, we divide distance into 6 intervals: [0,375), [375,750), [750,1500), [1500,3000), [3000,6000), and [6000,maximum). We consider the following free trade agreements for the f variable: EC/EU, EFTA, EEA, FTA, NFTA, CER, and a free-trade agreement between Turkey and EFTA.

For some pairs of countries, trade values are missing for 1989. Therefore, we cannot estimate δ_{nij} for some n, i, and j, which are part of our distance measure. There are 19*18*8 =2,736 observations of δ_{nij} possible in our data, of which 105 or 3.8% are missing. We proxy most missing observations by estimates from neighboring years. Six observations that cannot be proxied in this manner are proxied by estimates of δ_{ni} for total manufacturing.

[36] We have decided not to include Ireland, Netherlands, and Denmark because in these countries, in several industries, exports exceed output. This problem occurs because these countries are entrepôts. See Feenstra (2000) for discussion. Also, we have decided not to use ISIC industry 'Other' because of many irregularities in its data in many countries.

[37] Using value added data from UNIDO results in improbably high capital shares. See Shikher (2004a) for more detail.

[38] The table for Australia was for 1989.

Appendix C Extending the model to include endogenous capital accumulation and an international capital market

In this section, we develop two extensions of our model that will endogenize capital stock. The first extension will introduce endogenous capital accumulation, while the second will add an international capital market.

We start by extending the model to a dynamic setting in which capital stocks vary over time, thus creating a link between trade and growth.[39] We assume an exogenous savings rate, as in the Solow model.[40] Since we model individual industries, we are able to endogenously determine the price of the capital good separately from the prices of consumption goods, as shown in Section 2.1.[41] Our model makes the distinction between capital stock and financial capital that is used to buy the capital stock. The amount of savings and the quantity of investment are linked to each other by the price of capital.

The evolution of capital stock in country i is described by the following equation:

$$K_{it} = (1-\delta)\,K_{i,t-1} + I_{it}, \tag{21}$$

where δ is the depreciation rate, and I_{it} is total physical investment (i.e. number of machines bought). The value of investment is $B_{it} \equiv p^k_{it} I_{it}$.

Given the exogenous savings rate s_i, domestic investment is $B_{it} = s_i VA_{it}$. The quantity of capital good that can be bought with this amount is $I_{it} = s_i VA_{it}/p^k_{it}$. This quantity is higher when the price of capital is lower or when country income is higher. The steady-state capital stock is given by[42]

$$K_i = \frac{s_i VA_i}{\delta p^k_i}. \tag{22}$$

We also attempt to create a bridge between trade and open-economy macro models by incorporating a simple model of international investment. Admittedly, our representation of the international capital market is simple. We assume, for example, that savings can be freely moved between countries, an assumption that is likely to result in overestimated international capital flows. However, the goal at this point is not to model the capital market as realistically as possible, but simply to demonstrate how it can be integrated into the model.

With an international capital market, owners of capital in each country n can sell their machines domestically for the price p^k_{nt}, then take the proceeds to country i and buy machines there for p^k_{it} per machine.[43] When they do that, instead of receiving r_{nt}, they receive r_{it}. Competition ensures

[39] Some of the more prominent examples of the previous (mostly theoretical) literature that considered capital accumulation and international investment with relation to international trade are: Findlay (1984) and Smith (1984), who discuss growth and capital accumulation in the context of the Ricardian and Heckscher-Ohlin models; Grossman and Helpman (1995), who discuss trade in the context of a model with market imperfections and endogenous growth; and Baxter (1995), who analyzes international trade in the context of a business cycle.

[40] The static version of the model, developed in the main body of the paper, can be thought of as the short-run version of this dynamic model.

[41] Eaton and Kortum (2001b) estimate machinery prices across countries, but consider machinery industry in isolation. They do not take inter-industry trade into account, a fact that they discuss in the appendix to their paper.

[42] In a steady state, equation (22) is compatible with Ramsey-type consumer optimization framework where s varies according to the rate of time preference (and elasticity of intertemporal substitution), provided that there is no technological or population growth.

[43] This formulation assumes that there is a good that can be traded freely between countries.

that the (instantaneous) rate of return, adjusted for the price of capital, r_{nt}/p^k_{nt}, is the same in all countries. We call this number the world interest rate r^w.

Investment is now endogenous and can be negative.[44] The difference between domestic investment and domestic savings, $BF_{nt} \equiv B_{nt} - s_{nt}VA_{nt}$, is the net capital inflow into country n in period t. The negative of net capital inflow is the current account: $CA_{nt} = -BF_{nt}$. The total world savings are still given by $\sum_n s_{nt}VA_{nt}$. Country income VA_{nt} now includes return on savings invested in foreign countries.

In Appendix D, we use the extensions developed in this section to study the effects of a technological growth in the U.S. Machinery industry. We show the effects of endogenous capital accumulation and an international capital market on the results.

[44] Negative investment represents a sale of capital goods on domestic markets. These capital goods are bought either by consumers for final consumption or producers for intermediate consumption.

Appendix D Technological improvement with endogenous capital

In Appendix C, we created two extensions of the model that incorporated endogenous capital accumulation and an international capital market. In this appendix, we use these extensions to study how trade and investment transmit benefits (positive or negative) of technological progress across countries. In particular, we examine the effects of technological progress in the U.S. Machinery industry.

We consider two scenarios. In the first, capital is accumulated endogenously, but there is no international investment, so that trade is the only connection between countries. In the second scenario, we allow for the international movement of capital to see how it affects the results. We seek to answer the following questions.

How does technological progress in the Machinery industry of the United States, a major capital-producing country, affect prices and incomes around the world? Does the presence or absence of an international capital market make any difference?

The U.S. is likely to be better off with higher technology parameter in its Machinery industry, because it becomes more competitive internationally and is able to buy more capital with the same amount of savings. Other countries benefit from access to cheaper capital goods, but hurt by greater competition from the United States. In addition, if international investment is allowed, some of other countries' savings are invested into the U.S., where the rate of return is higher. What is the net effect on countries' incomes and capital stock?

Finally, is the world as a whole better off after the technological improvement in the U.S.? Does presence of international investment make any difference? Keep in mind that because of our assumption of free international movement of savings, we probably overestimate the effects of moving to open capital market.

We simulate a 20% increase of the technology parameter in the U.S. Machinery industry. This is a modest increase. For example, as shown on Table 8, the technology parameter in the German Machinery industry is 1/2 of the U.S.'s and the technology parameter in the U.K. is 1/5 of the U.S.'s. Increasing the technology parameter in the U.S. Machinery industry by 20% makes it nearly equal to the Japanese, which is presently about 22.8% higher than the U.S.'s.

Tables 19a-k show the effects of this change on prices, terms of trade, incomes, factor stocks, and measured productivity.[45] They show the impact (first-period) and steady state effects for two scenarios: one with and the other without international investment.

We can see that manufacturing consumption price levels fall in all countries. The greatest decline is not in the U.S., but in Canada. The second largest is in the U.S., and third largest is in Mexico. Table 19c shows that prices in industries other then Machinery actually rise in the U.S. This is because factors shift from those industries to the Machinery industry, and the U.S. has to import more of those goods. Canada and Mexico, being close to the U.S., are able to benefit the most from price declines in U.S. Machinery goods, while also enjoying higher domestic production and lower imports of other goods.

United States and its two neighbors enjoy even lower prices when international investment is possible, while other countries see smaller price declines. This is because with an international capital market, U.S. capital does not shift as much from other industries into Machinery. Instead,

[45] Manufacturing consumption price level is calculated as $p_n = \prod_j p_{nj}^{\psi_j/\psi_j^M}$, where ψ_j^M is the portion of country income spent on manufacturing goods. This price level is used to calculate real wages, country income, and consumption.

it comes from other countries. Labor, however, is not internationally mobile, so it still has to come from other industries. With international investment, prices in U.S. industries other than Machinery still rise (not shown), but less than they do without international investment.

Technological improvement in the U.S. Machinery industry improves the terms of trade for the U.S. and countries that are importers of Machinery.[46] Countries that are producers and exporters of Machinery see their terms of trade worsen.

Real manufacturing value added (income) rises in the U.S. by 2.7-3.5%. In all other countries, it falls by less than 1%. This effect is more pronounced with international capital markets, as savings move from other countries into the United States. Real wages are similarly affected.

As we can see, incomes in many countries fall even though their terms of trade improve. The main reason for this result is the presence of nontraded goods with fixed prices. Because these goods are inputs into the production of traded goods, and their prices are fixed, factor prices have to decline in order to reduce production costs of traded goods (to remain competitive with the U.S.).

Differences of transport costs are another reason for the decline in some countries' incomes. While poorer countries are good candidates to benefit from higher U.S. Machinery technology (since they are major net importers of Machinery), the high costs of transporting U.S. Machinery into these countries means that their Machinery prices do not fall as much.

Table 19h shows that without international investment, all countries accumulate additional capital because the price of the capital good falls. However, in the U.S., the increased demand for capital stock outpaces supply, and the interest rate rises by about 1.5% in the steady state. Interest rates in all other countries fall. Interestingly, interest rates in Canada and Mexico initially rise and then fall. They rise because availability of cheaper intermediate inputs from the U.S. increases demand for capital in those countries. Eventually, with higher income, they are able to accumulate additional capital and their interest rates fall.

With international investment, all countries invest in the United States, because productivity there has increased. The capital stock in the U.S. increases by 3.8% versus 1.65% in the absence of international investment. All other countries, except Mexico, loose capital stock. The world interest rate increases initially, but then decreases as additional capital is accumulated. It settles just 0.02% above its starting value.

Foreign investment into the U.S. in the steady state constitutes about 2% of total U.S. investment. Japan, being a large economy and facing the lowest interest rate in the absence of international investment, is the largest investor into the U.S., with 43% of total foreign investment.[47] Germany is the second-largest with 15%, while U.K. and France each have 8-9%.

What happens to the total factor productivity (TFP)? Table 19j shows TFP changes for the case of no international investment.[48] It shows that total factor productivity rises in all industries in the Unites States, with the largest increase being in the Machinery industry. TFP also rises in the Machinery industries of Canada and Mexico. Total factor productivities fall in other countries.

Table 19k shows the world-wide effects of the technological change in the U.S. Machinery indus-

[46] Changes in the terms of trade are calculated as $\sum_j NE_{nj1}\left(\frac{p_{nj2}}{p_{nj1}}\right) - \sum_j NE_{nj1}$, where NE_{njt} is the value of net exports of country n in industry j and period t (Dixit and Norman, 1980).

[47] Japan has the lowest interest rate in the absence of international investment, as shown on Table 19g. Its interest rate declines by 0.93% in the steady state of the basic model.

[48] TFP is calculated as $\log A_{nj} = \log\left(VA_{nj}/p_{nj}\right) - (\alpha/(\alpha+\beta))\log K_{nj} - (\beta/\left(\alpha+\beta\right))\log L_{nj}$. In that expression, VA_{nj}/p_{nj} measures the real value added in industry j of country n. Remember that K_{nj} is measured in real terms.

try. Without international investment, world capital stock rises by about 0.8% in the steady state. World real manufacturing income rises by about 0.7%. Presence of an international capital market results in a more efficient allocation of resources across countries. Therefore, an international capital market has a positive effect on world capital stock and world income, though the effect is not large. Real world income rises 0.03 percentage points more with international investment than without it.

In conclusion, we can answer the questions we posed in the beginning of this section. Technological progress in U.S. Machinery industry increases world income and capital stock. However, there is a redistribution of income from other countries to the United States. In fact, other countries suffer a loss of real income. For them, the availability of cheaper capital is outweighed by the increased competitiveness of the United States on the world markets.[49] Presence of an international capital market has a positive effect on world income, but also increases the redistribution of income: other countries are worse off with international investment than without it.

The effect on the world capital stock is positive. Without international investment, all countries are able to accumulate additional capital stock. With international investment, world capital stock grows even more, but for all countries except the United States and Mexico, the effect of capital outflows is greater than the effect of cheaper capital. As the result, they lose capital stock.

[49] This result, however, is largely driven by fixed prices of nontraded goods.

Appendix E Technology in the nontraded sector

How can we estimate the technology parameter in the nontraded sector? In Eaton and Kortum (2002), technology parameters are calculated from estimated exporter dummies, which requires goods to be traded. In this paper, we obtain technology parameters by fitting a subset of model equations to domestic data. Goods still have to be traded, though. If they are not, output is equal spending and solution is impossible. So, how can we find technology parameters for goods that are not traded? We can do it by exploiting inter-industry linkages.

Remember that the price index of the nontraded sector in the baseline economy is normalized to one. The cost equation (17), applied to the nontraded sector S ('services') is

$$c_{iS} = r_i^{\alpha} w_i^{\beta} \prod_{m=1}^{J} \left(T_{im}^{1/\theta} c_{im} \right)^{\eta_{Sm}}, \tag{23}$$

while the equation for prices (3) is

$$p_{iS} = \gamma T_{iS}^{-1/\theta} c_{iS} \tag{24}$$

or

$$c_{iS} = \frac{1}{\gamma} T^{1/\theta}. \tag{25}$$

Adding equations (23) and (25) to the baseline model allows us to estimate the technology parameter in the nontraded sector.[50]

For simulation, output and factor stock equations for the nontraded sector are:

$$Q_{iS} = \left(\sum_{m=1}^{J} \frac{\eta_{mS} \left(1 - \alpha_m - \beta_m\right)}{\beta_m} w_i L_{im} \right) + B_{iS} + \psi_{iS} V A_i \tag{26}$$

and

$$K_{iS} = \frac{\alpha_S Q_{iS}}{r_i} \text{ and } L_{iS} = \frac{\beta_S Q_{iS}}{w_i}. \tag{27}$$

[50] This method allows us to estimate technology parameter for only one nontraded industry (which is why we use the word 'sector'). Also note that during simulations the price index of nontraded goods may change and be different from one. The normalization is only in the baseline economy.

Table 2a List of countries in the dataset

Country Name
Australia
Austria
Canada
Finland
France
Germany (West)
Greece
Italy
Japan
Korea
Mexico
New Zealand
Norway
Portugal
Spain
Sweden
Turkey
United Kingdom
United States

Table 2b List of industries in the dataset

ISIC	Industry name
1	Food
2	Textile
3	Wood
4	Paper
5	Chemicals
6	Nonmetals
7	Metals
8	Machinery

Table 3 Shares of factors and inputs

Industry	Capital	Labor	Inputs	Cap. in VA
Food	0.062	0.103	0.835	0.37
Textile	0.058	0.201	0.741	0.22
Wood	0.064	0.182	0.755	0.26
Paper	0.081	0.185	0.733	0.31
Chemicals	0.082	0.115	0.803	0.42
Nonmet.	0.106	0.185	0.709	0.36
Metals	0.086	0.133	0.781	0.39
Machinery	0.071	0.186	0.743	0.28

Table 4 Industry shares in intermediate and investment goods

SOURCES, m	USES, j: Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	Capital
Food	**0.224**	0.001	0.002	0.042	0.045	0.012	0.001	0.034	0.002
Textile	0.017	**0.487**	0.001	0.024	0.125	0.001	0.001	0.019	0.002
Wood	0.002	0.040	**0.281**	0.019	0.084	0.013	0.023	0.058	0.011
Paper	0.006	0.008	0.020	**0.439**	0.090	0.002	0.003	0.027	0.001
Chemicals	0.014	0.008	0.002	0.023	**0.392**	0.007	0.012	0.030	0.004
Nonmetals	0.003	0.005	0.007	0.045	0.100	**0.186**	0.020	0.050	0.001
Metals	0.001	0.002	0.002	0.004	0.049	0.013	**0.459**	0.046	0.004
Machinery	0.002	0.008	0.007	0.014	0.073	0.011	0.152	**0.440**	0.661
Manuf.	0.268	0.559	0.322	0.610	0.959	0.245	0.671	0.704	0.686
Nonmanuf.	0.732	0.441	0.678	0.390	0.041	0.755	0.329	0.296	0.314
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note: The above data is the average of the following countries and years:
Countries: Australia, Canada, France, Germany, Japan, UK, US
Australia: 1989, all other countries: 1990

Table 5 Average transport cost in each industry

ISIC2	**Av. transport cost**
Food	2.45
Textile	2.02
Wood	2.57
Paper	2.44
Chemicals	2.21
Nonmetals	2.38
Metals	2.04
Machinery	2.01
Average	2.27
Max	6.62
Min	~1
St. Dev.	0.77

Table 6 Estimated relative import barriers for 1989

	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
Australia	1.28	1.51	1.92	1.43	1.45	1.62	1.29	1.51
Austria	2.20	1.41	2.31	1.57	1.74	1.73	1.81	1.62
Canada	1.25	1.28	1.26	1.07	1.42	1.42	1.05	1.38
Finland	2.59	1.74	2.02	1.46	1.77	2.00	1.62	1.80
France	1.34	1.22	1.70	1.35	1.29	1.38	1.37	1.40
Germany	1.48	1.09	1.43	1.13	1.20	1.24	1.24	1.21
Greece	1.72	1.80	2.73	2.18	2.37	1.93	1.88	2.61
Italy	1.39	1.10	1.40	1.33	1.35	1.30	1.50	1.41
Japan	1.50	1.22	1.55	1.37	1.18	1.19	1.16	1.29
Korea	1.64	0.96	1.82	1.44	1.28	1.49	1.18	1.38
Mexico	1.77	1.81	2.10	2.11	1.67	1.81	1.70	1.86
New Zeal.	1.27	1.59	2.04	1.48	1.52	1.91	1.34	1.88
Norway	1.76	1.73	2.33	1.81	1.58	2.01	1.41	1.90
Portugal	1.91	1.14	2.39	1.73	2.25	1.80	1.80	1.86
Spain	1.58	1.59	1.95	1.54	1.61	1.60	1.63	1.72
Sweden	1.87	1.30	1.80	1.30	1.48	1.54	1.41	1.36
Turkey	2.37	2.09	3.29	2.98	2.28	2.11	1.98	2.83
U.K.	1.36	1.19	1.59	1.20	1.26	1.35	1.28	1.27
U.S.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Av. non-US	1.68	1.43	1.98	1.58	1.60	1.63	1.48	1.68

Table 7 Country rankings according to their estimated relative import barriers

Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
U.S.	Korea	U.S.	U.S.	U.S.	U.S.	U.S.	U.S.
Canada	U.S.	Canada	Canada	Japan	Japan	Canada	Germany
New Zeal.	Germany	Italy	Germany	Germany	Germany	Japan	U.K.
Australia	Italy	Germany	U.K.	U.K.	Italy	Korea	Japan
France	Portugal	Japan	Sweden	Korea	U.K.	Germany	Sweden
U.K.	U.K.	U.K.	Italy	France	France	U.K.	Canada
Italy	France	France	France	Italy	Canada	Australia	Korea
Germany	Japan	Sweden	Japan	Canada	Korea	New Zeal.	France
Japan	Canada	Korea	Australia	Australia	Sweden	France	Italy
Spain	Sweden	Australia	Korea	Sweden	Spain	Norway	Australia
Korea	Austria	Spain	Finland	New Zeal.	Australia	Sweden	Austria
Greece	Australia	Finland	New Zeal.	Norway	Austria	Italy	Spain
Norway	New Zeal.	New Zeal.	Spain	Spain	Portugal	Finland	Finland
Mexico	Spain	Mexico	Austria	Mexico	Mexico	Spain	Portugal
Sweden	Norway	Austria	Portugal	Austria	New Zeal.	Mexico	Mexico
Portugal	Finland	Norway	Norway	Finland	Greece	Portugal	New Zeal.
Austria	Greece	Portugal	Mexico	Portugal	Finland	Austria	Norway
Turkey	Mexico	Greece	Greece	Turkey	Norway	Greece	Greece
Finland	Turkey	Turkey	Turkey	Greece	Turkey	Turkey	Turkey

Table 8 Technology parameters and capital-labor ratios, relative to the United States

	Technology parameters								
	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery	Capital
Australia	0.253	0.098	0.018	0.040	0.048	0.045	0.408	0.054	0.524
Austria	0.027	0.154	0.029	0.087	0.063	0.201	0.137	0.073	0.604
Canada	0.266	0.292	0.503	0.753	0.153	0.139	0.914	0.149	0.799
Finland	0.013	0.080	0.089	0.434	0.056	0.048	0.238	0.072	0.641
France	0.368	0.702	0.138	0.260	0.372	0.792	0.587	0.318	0.921
Germany	0.215	0.676	0.220	0.332	0.522	0.914	0.683	0.521	0.894
Greece	0.043	0.044	0.001	0.003	0.008	0.033	0.040	0.002	0.202
Italy	0.178	1.435	0.339	0.206	0.249	1.387	0.369	0.356	0.884
Japan	0.080	0.776	0.119	0.309	0.571	1.491	1.007	1.228	0.979
Korea	0.032	0.319	0.008	0.017	0.069	0.043	0.148	0.061	0.263
Mexico	0.010	0.009	0.001	0.001	0.017	0.010	0.022	0.003	0.121
New Zeal.	0.358	0.058	0.020	0.042	0.031	0.009	0.056	0.015	0.380
Norway	0.101	0.032	0.030	0.123	0.084	0.036	0.313	0.053	0.684
Portugal	0.018	0.028	0.004	0.011	0.006	0.024	0.011	0.004	0.171
Spain	0.117	0.140	0.026	0.058	0.080	0.211	0.193	0.048	0.428
Sweden	0.033	0.067	0.076	0.255	0.088	0.092	0.248	0.135	0.644
Turkey	0.014	0.019	0.000	0.000	0.007	0.015	0.027	0.001	0.090
U.K.	0.232	0.320	0.055	0.166	0.256	0.342	0.352	0.197	0.624
U.S.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 9 Country rankings according to their technology parameters and capital-labor ratios

Technology parameters								
Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery	Capital
U.S.	Italy	U.S.	U.S.	U.S.	Japan	Japan	Japan	U.S.
France	U.S.	Canada	Canada	Japan	Italy	U.S.	U.S.	Japan
New Zeal.	Japan	Italy	Finland	Germany	U.S.	Canada	Germany	France
Canada	France	Germany	Germany	France	Germany	Germany	Italy	Germany
Australia	Germany	France	Japan	U.K.	France	France	France	Italy
U.K.	U.K.	Japan	France	Italy	U.K.	Australia	U.K.	Canada
Germany	Korea	Finland	Sweden	Canada	Spain	Italy	Canada	Norway
Italy	Canada	Sweden	Italy	Sweden	Austria	U.K.	Sweden	Sweden
Spain	Austria	U.K.	U.K.	Norway	Canada	Norway	Austria	Finland
Norway	Spain	Norway	Norway	Spain	Sweden	Sweden	Finland	U.K.
Japan	Australia	Austria	Austria	Korea	Finland	Finland	Korea	Austria
Greece	Finland	Spain	Spain	Austria	Australia	Spain	Australia	Australia
Sweden	Sweden	New Zeal.	New Zeal.	Finland	Korea	Korea	Norway	Spain
Korea	New Zeal.	Australia	Australia	Australia	Norway	Austria	Spain	New Zeal.
Austria	Greece	Korea	Korea	New Zeal.	Greece	New Zeal.	New Zeal.	Korea
Portugal	Norway	Portugal	Portugal	Mexico	Portugal	Greece	Portugal	Greece
Turkey	Portugal	Greece	Greece	Greece	Turkey	Turkey	Mexico	Portugal
Finland	Turkey	Mexico	Mexico	Turkey	Mexico	Mexico	Greece	Mexico
Mexico	Mexico	Turkey	Turkey	Portugal	New Zeal.	Portugal	Turkey	Turkey

Table 10 Average percent deviations of predicted from actual trade flows by industry

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	World
% deviation	3.59	7.47	6.18	4.80	8.46	4.76	9.70	11.17	7.05

Table 11 Predicted and actual Grubel-Lloyd intra-industry trade indices

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	World
Model	0.44	0.33	0.36	0.30	0.50	0.38	0.50	0.39	0.40
Data	0.49	0.39	0.42	0.34	0.54	0.47	0.55	0.42	0.45

Table 12 Country-level diagnostics

	Av. % deviation of trade flows	GL IIT index	
		Model	Data
Australia	10.61	0.23	0.28
Austria	-5.36	0.44	0.49
Canada	13.36	0.42	0.45
Finland	-3.30	0.41	0.45
France	3.65	0.51	0.56
Germany	3.51	0.46	0.53
Greece	17.99	0.33	0.37
Italy	9.21	0.42	0.48
Japan	9.39	0.40	0.43
Korea	9.83	0.41	0.45
Mexico	8.47	0.36	0.36
New Zealand	9.57	0.25	0.32
Norway	10.28	0.38	0.46
Portugal	7.04	0.41	0.44
Spain	2.48	0.50	0.54
Sweden	7.37	0.43	0.48
Turkey	-8.38	0.28	0.35
United Kingdom	10.95	0.48	0.55
United States	14.59	0.49	0.55

Tables 13a-b Accounting for international trade

Table 13a Accounting for volume of trade

Determinants of trade that are removed	Percent change in the volume of trade
Industry-level	
Factor endowments	1.36%
Comparative advantage	-5.09%
Tastes	6.08%
Product-level	
Comparative advantage	-93.40%

Table 13b Accounting for inter- and intra-industry trade

	Change in GL index	% contri-bution to total	GL index value (balance)
Current value of GL index			0.46
Removing determinants of trade:			
Industry-level			
Factor endowments	0.01	3%	0.47
Comparative advantage	0.06	12%	0.53
Tastes	0.04	8%	0.57
Geography-related	0.39	78%	0.96
Total industry-level	0.50	100%	0.96
Product-level			
Comparative advantage	-0.43	N/A	0.03

Table 14a Removing industry-level comparative advantages: percent changes of exports

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	-196%	53%	96%	72%	58%	58%	-209%	28%
Austria	87%	-8%	40%	-52%	26%	-46%	-22%	7%
Canada	-27%	6%	-125%	-161%	69%	70%	-120%	58%
Finland	194%	93%	-105%	-248%	71%	129%	-63%	35%
France	-31%	-25%	37%	29%	-3%	-18%	11%	18%
Germany	88%	23%	0%	22%	-20%	1%	26%	-12%
Greece	-166%	-129%	198%	124%	48%	-80%	-109%	187%
Italy	108%	-114%	-64%	66%	66%	-95%	102%	10%
Japan	273%	-11%	232%	149%	17%	-76%	-18%	-94%
Korea	-48%	-192%	183%	187%	-19%	115%	-82%	11%
Mexico	-62%	-40%	205%	199%	-136%	-56%	-142%	57%
New Zealand	-298%	-4%	-105%	-119%	20%	152%	22%	115%
Norway	-81%	161%	32%	-112%	-25%	92%	-122%	46%
Portugal	-102%	-68%	-12%	-75%	58%	-59%	50%	87%
Spain	-41%	-39%	35%	5%	-3%	-58%	-56%	50%
Sweden	147%	129%	-45%	-132%	40%	69%	-33%	-11%
Turkey	-208%	-140%	194%	380%	-38%	-60%	-180%	227%
United Kingdom	-7%	7%	124%	15%	-38%	4%	-6%	2%
United States	-84%	78%	-91%	-7%	-14%	24%	87%	7%

Table 14b Removing industry-level comparative advantages: percent changes of imports

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	177%	-55%	-125%	-74%	-55%	-123%	155%	-27%
Austria	-49%	1%	-18%	22%	-15%	25%	14%	-3%
Canada	28%	-29%	68%	87%	-44%	-64%	98%	-17%
Finland	-144%	-32%	61%	135%	-49%	-109%	37%	-17%
France	51%	-7%	-41%	-30%	6%	-3%	15%	-8%
Germany	-79%	-40%	-10%	-44%	20%	-10%	-19%	6%
Greece	98%	18%	-153%	-120%	-21%	26%	64%	-91%
Italy	-50%	40%	56%	-69%	-48%	66%	-60%	-4%
Japan	-265%	-87%	-207%	-182%	-24%	70%	-35%	80%
Korea	-74%	-18%	-237%	-182%	8%	-117%	40%	-23%
Mexico	47%	24%	-59%	-138%	66%	31%	74%	-17%
New Zealand	190%	-1%	33%	48%	-7%	-173%	67%	-69%
Norway	134%	-22%	-36%	21%	15%	-75%	-14%	-22%
Portugal	56%	-53%	1%	28%	-36%	29%	31%	-7%
Spain	55%	1%	-32%	-18%	8%	33%	72%	-24%
Sweden	-105%	-22%	16%	57%	-25%	-44%	-5%	0%
Turkey	115%	82%	-185%	-389%	25%	62%	147%	-167%
United Kingdom	39%	-23%	-102%	-42%	28%	-21%	3%	-2%
United States	69%	-139%	28%	-35%	31%	-47%	-80%	-9%

Table 15 Effects of capital stock on specialization

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Simulation	-1.173	-0.718	-0.414	-0.014	0.761	-0.073	1.513	0.117
Regression	-0.397	-0.980	-0.270	-0.257	0.203	-0.073	0.194	0.471

Figure 1 Simulation and regression estimates

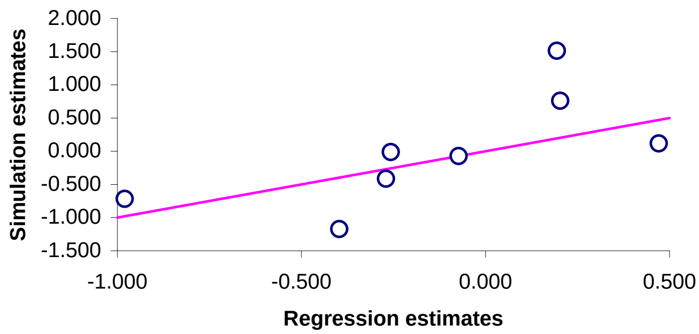

Table 16 Simulated capital stock coefficients

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	-1.34	-0.77	-0.74	-0.60	0.52	-0.42	2.62	0.72
Austria	-1.59	-1.03	-0.72	0.27	1.57	-0.05	2.03	-0.47
Canada	-1.28	-0.67	-0.55	0.38	0.67	0.00	1.76	-0.31
Finland	-1.95	-0.41	-0.85	1.07	0.97	-0.26	1.59	-0.15
France	-1.12	-0.67	-0.28	-0.30	1.09	0.00	1.38	-0.10
Germany	-0.80	-0.49	-0.25	0.11	0.74	0.03	1.29	-0.63
Greece	-1.21	-1.58	-0.22	0.15	0.64	0.11	1.82	0.28
Italy	-0.75	-1.53	-0.20	-0.13	1.05	0.21	1.07	0.28
Japan	-0.52	-0.22	-0.11	-0.38	0.02	-0.19	0.78	0.62
Korea	-0.64	-1.14	-0.13	-0.17	0.09	-0.25	1.44	0.78
Mexico	-1.67	-0.64	-0.02	-0.04	0.82	-0.12	1.98	-0.32
New Zealand	0.24	-1.03	-0.74	-0.29	1.27	-0.10	1.09	-0.43
Norway	-2.08	-0.21	-0.74	-0.46	2.01	0.10	2.88	-1.49
Portugal	-1.08	-2.03	-0.41	0.81	1.04	0.45	0.72	0.51
Spain	-1.88	-0.69	-0.39	-0.12	0.62	-0.23	1.41	1.28
Sweden	-1.33	-0.26	-0.92	0.33	1.28	0.06	1.77	-0.93
Turkey	-1.30	0.46	-0.09	0.07	-0.68	-0.43	0.90	1.05
United Kingdom	-1.23	-0.53	-0.33	-0.41	0.82	-0.29	1.33	0.63
United States	-0.75	-0.22	-0.17	-0.55	-0.10	-0.02	0.87	0.93

Table 16a Summary of the simulated capital stock coefficients

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Average coeff.	-1.173	-0.718	-0.414	-0.014	0.761	-0.073	1.513	0.117
Std. dev.	0.56	0.58	0.29	0.45	0.62	0.22	0.59	0.74
Max	0.24	0.46	-0.02	1.07	2.01	0.45	2.88	1.28
Min	-2.08	-2.03	-0.92	-0.60	-0.68	-0.43	0.72	-1.49

Table 17 Summary of elasticities of specialization with respect to capital

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Av. elasticity	-0.087	-0.083	-0.079	-0.004	0.052	-0.012	0.178	0.005
Std. dev.	0.033	0.035	0.025	0.033	0.045	0.033	0.050	0.021
Max	0.009	0.022	-0.031	0.070	0.156	0.054	0.250	0.052
Min	-0.143	-0.126	-0.117	-0.051	-0.023	-0.061	0.064	-0.040

Table 18a Elasticities of specialization with respect to technology parameters

Source \ Effect	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Food	**0.214**	-0.039	-0.031	-0.015	-0.024	-0.022	-0.058	-0.047
Textile	-0.041	**0.681**	-0.060	-0.059	-0.036	-0.063	-0.104	-0.099
Wood	-0.011	-0.020	**0.394**	-0.014	-0.013	-0.012	-0.025	-0.022
Paper	-0.025	-0.065	-0.038	**0.445**	-0.036	-0.044	-0.093	-0.076
Chemicals	-0.044	-0.052	-0.059	-0.051	**0.411**	-0.054	-0.099	-0.084
Nonmetals	-0.009	-0.023	-0.011	-0.014	-0.011	**0.274**	-0.016	-0.017
Metals	-0.051	-0.111	-0.067	-0.089	-0.065	-0.053	**0.691**	-0.037
Machinery	-0.147	-0.331	-0.205	-0.252	-0.183	-0.172	-0.096	**0.395**

Table 18b Standard deviation of elasticities

Source \ Effect	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Food	**0.113**	0.047	0.034	0.027	0.034	0.023	0.067	0.048
Textile	0.040	**0.226**	0.060	0.059	0.036	0.059	0.085	0.093
Wood	0.007	0.015	**0.202**	0.015	0.010	0.009	0.020	0.018
Paper	0.024	0.071	0.044	**0.221**	0.038	0.044	0.087	0.075
Chemicals	0.015	0.028	0.024	0.027	**0.183**	0.022	0.037	0.030
Nonmetals	0.005	0.013	0.008	0.010	0.007	**0.123**	0.011	0.012
Metals	0.020	0.045	0.034	0.041	0.034	0.025	**0.256**	0.036
Machinery	0.037	0.111	0.086	0.108	0.066	0.061	0.087	**0.156**

Table 18c Minimum of elasticities

Source \ Effect	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Food	**0.057**	-0.200	-0.154	-0.112	-0.151	-0.095	-0.314	-0.220
Textile	-0.137	**0.210**	-0.184	-0.230	-0.117	-0.193	-0.276	-0.281
Wood	-0.028	-0.051	**0.108**	-0.046	-0.029	-0.026	-0.065	-0.055
Paper	-0.091	-0.291	-0.173	**0.068**	-0.145	-0.161	-0.350	-0.308
Chemicals	-0.069	-0.097	-0.116	-0.091	**0.112**	-0.091	-0.163	-0.128
Nonmetals	-0.021	-0.054	-0.028	-0.040	-0.025	**0.054**	-0.043	-0.046
Metals	-0.091	-0.208	-0.162	-0.166	-0.167	-0.115	**0.183**	-0.141
Machinery	-0.187	-0.527	-0.351	-0.475	-0.299	-0.266	-0.283	**0.079**

Table 18d Maximum of elasticities

Source \ Effect	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Food	**0.537**	0.000	-0.006	0.012	0.000	-0.003	-0.011	-0.008
Textile	-0.006	**0.975**	-0.005	-0.005	-0.002	-0.009	-0.018	-0.014
Wood	-0.001	-0.002	**0.915**	0.003	-0.001	-0.001	-0.001	0.000
Paper	-0.001	-0.003	0.003	**0.793**	-0.001	-0.004	-0.009	-0.007
Chemicals	-0.015	-0.004	-0.013	-0.009	**0.812**	-0.014	-0.017	-0.017
Nonmetals	-0.002	-0.004	-0.002	-0.002	-0.002	**0.464**	-0.002	-0.003
Metals	-0.021	-0.041	-0.026	-0.027	-0.021	-0.020	**1.108**	0.004
Machinery	-0.070	-0.169	-0.031	-0.088	-0.072	-0.064	0.043	**0.725**

Tables 19a-c Effects of a 20% increase in the technology parameter of the U.S. Machinery industry

	a. Manufacturing consumption price level				b. Capital good price			
	No int'l investment		With int'l investment		No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.	Impact	S.S.	Impact	S.S.
Australia	-0.48%	-0.56%	-0.44%	-0.52%	-0.50%	-0.56%	-0.47%	-0.54%
Austria	-0.39%	-0.46%	-0.32%	-0.40%	-0.36%	-0.41%	-0.31%	-0.37%
Canada	-0.81%	-0.92%	-0.86%	-0.94%	-0.88%	-0.96%	-0.93%	-0.99%
Finland	-0.38%	-0.45%	-0.32%	-0.40%	-0.38%	-0.43%	-0.33%	-0.40%
France	-0.39%	-0.46%	-0.32%	-0.41%	-0.36%	-0.41%	-0.31%	-0.38%
Germany	-0.43%	-0.49%	-0.35%	-0.44%	-0.38%	-0.44%	-0.34%	-0.40%
Greece	-0.31%	-0.38%	-0.24%	-0.33%	-0.35%	-0.40%	-0.30%	-0.37%
Italy	-0.35%	-0.42%	-0.27%	-0.36%	-0.33%	-0.38%	-0.28%	-0.35%
Japan	-0.48%	-0.55%	-0.40%	-0.49%	-0.41%	-0.46%	-0.35%	-0.42%
Korea	-0.44%	-0.51%	-0.39%	-0.48%	-0.45%	-0.51%	-0.42%	-0.49%
Mexico	-0.63%	-0.74%	-0.70%	-0.79%	-0.90%	-0.99%	-0.96%	-1.03%
New Zealand	-0.44%	-0.51%	-0.40%	-0.48%	-0.46%	-0.52%	-0.43%	-0.50%
Norway	-0.45%	-0.52%	-0.39%	-0.48%	-0.42%	-0.47%	-0.38%	-0.44%
Portugal	-0.34%	-0.40%	-0.27%	-0.35%	-0.35%	-0.41%	-0.31%	-0.37%
Spain	-0.33%	-0.40%	-0.26%	-0.35%	-0.34%	-0.39%	-0.29%	-0.35%
Sweden	-0.47%	-0.54%	-0.41%	-0.49%	-0.44%	-0.49%	-0.40%	-0.46%
Turkey	-0.25%	-0.31%	-0.18%	-0.27%	-0.33%	-0.38%	-0.29%	-0.35%
United Kingdom	-0.45%	-0.52%	-0.39%	-0.47%	-0.43%	-0.48%	-0.39%	-0.45%
United States	-0.64%	-0.77%	-0.77%	-0.86%	-1.27%	-1.36%	-1.34%	-1.41%

c. Price changes in the steady state of the basic model

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	-0.28%	-0.47%	-0.41%	-0.44%	-0.30%	-0.43%	-0.44%	-0.83%
Austria	-0.26%	-0.48%	-0.41%	-0.46%	-0.34%	-0.42%	-0.42%	-0.61%
Canada	-0.34%	-0.49%	-0.42%	-0.44%	-0.31%	-0.42%	-0.28%	-1.45%
Finland	-0.25%	-0.46%	-0.39%	-0.44%	-0.33%	-0.40%	-0.41%	-0.64%
France	-0.26%	-0.46%	-0.40%	-0.45%	-0.33%	-0.41%	-0.40%	-0.61%
Germany	-0.29%	-0.48%	-0.44%	-0.49%	-0.37%	-0.46%	-0.44%	-0.65%
Greece	-0.21%	-0.40%	-0.32%	-0.37%	-0.28%	-0.32%	-0.35%	-0.60%
Italy	-0.24%	-0.44%	-0.36%	-0.42%	-0.32%	-0.39%	-0.38%	-0.56%
Japan	-0.31%	-0.60%	-0.44%	-0.56%	-0.42%	-0.53%	-0.51%	-0.68%
Korea	-0.25%	-0.49%	-0.27%	-0.39%	-0.33%	-0.44%	-0.44%	-0.76%
Mexico	-0.21%	-0.14%	0.20%	-0.09%	-0.17%	-0.36%	-0.23%	-1.50%
New Zealand	-0.24%	-0.41%	-0.36%	-0.39%	-0.26%	-0.37%	-0.43%	-0.77%
Norway	-0.27%	-0.46%	-0.42%	-0.46%	-0.34%	-0.42%	-0.43%	-0.70%
Portugal	-0.19%	-0.46%	-0.33%	-0.37%	-0.29%	-0.34%	-0.39%	-0.60%
Spain	-0.22%	-0.41%	-0.34%	-0.39%	-0.29%	-0.36%	-0.36%	-0.58%
Sweden	-0.31%	-0.46%	-0.47%	-0.53%	-0.37%	-0.47%	-0.45%	-0.73%
Turkey	-0.16%	-0.31%	-0.26%	-0.30%	-0.23%	-0.28%	-0.29%	-0.57%
United Kingdom	-0.29%	-0.49%	-0.44%	-0.49%	-0.36%	-0.46%	-0.42%	-0.72%
United States	0.27%	0.46%	0.39%	0.55%	0.33%	0.39%	0.24%	-2.08%

Tables 19d-g Effects of a 20% increase in the technology parameters of the U.S. Machinery industry

	d. Terms of trade				e. Real manufacturing income			
	No int'l investment		With int'l investment		No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.	Impact	S.S.	Impact	S.S.
Australia	1.5E+08	1.7E+08	1.5E+08	1.5E+08	-0.37%	-0.33%	-0.61%	-0.52%
Austria	2.4E+07	2.8E+07	2.2E+07	2.2E+07	-0.43%	-0.43%	-0.72%	-0.63%
Canada	2.6E+08	2.7E+08	2.7E+08	2.7E+08	-0.31%	-0.22%	-0.54%	-0.45%
Finland	7.5E+05	-5.9E+05	3.0E+06	2.8E+06	-0.38%	-0.38%	-0.65%	-0.57%
France	1.1E+08	1.2E+08	9.6E+07	9.8E+07	-0.43%	-0.43%	-0.71%	-0.62%
Germany	-5.4E+08	-6.2E+08	-4.6E+08	-4.7E+08	-0.55%	-0.56%	-0.88%	-0.79%
Greece	3.6E+07	4.3E+07	3.0E+07	3.0E+07	-0.20%	-0.19%	-0.38%	-0.30%
Italy	-6.8E+07	-7.9E+07	-6.7E+07	-6.8E+07	-0.40%	-0.40%	-0.68%	-0.60%
Japan	-7.6E+08	-8.7E+08	-6.7E+08	-6.8E+08	-0.65%	-0.67%	-1.03%	-0.94%
Korea	-6.8E+07	-8.0E+07	-6.9E+07	-7.0E+07	-0.44%	-0.45%	-0.80%	-0.71%
Mexico	1.5E+08	1.7E+08	1.6E+08	1.6E+08	-0.15%	-0.04%	-0.25%	-0.17%
New Zealand	1.8E+07	2.0E+07	1.9E+07	1.9E+07	-0.22%	-0.20%	-0.43%	-0.34%
Norway	3.2E+07	3.6E+07	3.3E+07	3.3E+07	-0.34%	-0.33%	-0.60%	-0.51%
Portugal	2.3E+07	2.7E+07	1.9E+07	1.9E+07	-0.24%	-0.23%	-0.45%	-0.36%
Spain	9.7E+07	1.1E+08	8.2E+07	8.4E+07	-0.33%	-0.33%	-0.56%	-0.48%
Sweden	-3.3E+07	-3.8E+07	-2.8E+07	-2.9E+07	-0.55%	-0.55%	-0.88%	-0.79%
Turkey	1.7E+07	2.0E+07	1.5E+07	1.6E+07	-0.21%	-0.20%	-0.38%	-0.29%
United Kingdom	1.9E+08	2.2E+08	1.7E+08	1.7E+08	-0.50%	-0.49%	-0.79%	-0.71%
United States	1.5E+09	1.7E+09	1.7E+09	1.7E+09	2.70%	2.98%	3.37%	3.46%

	f. Real wage				g. Interest rate			
	No int'l investment		With int'l investment		No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.	Impact	S.S.	Impact	S.S.
Australia	-0.41%	-0.37%	-0.65%	-0.56%	-0.31%	-0.72%	0.62%	0.02%
Austria	-0.46%	-0.46%	-0.74%	-0.66%	-0.44%	-0.72%	0.62%	0.02%
Canada	-0.51%	-0.41%	-0.72%	-0.64%	0.10%	-0.58%	0.62%	0.02%
Finland	-0.41%	-0.41%	-0.68%	-0.59%	-0.36%	-0.66%	0.62%	0.02%
France	-0.47%	-0.46%	-0.74%	-0.65%	-0.41%	-0.70%	0.62%	0.02%
Germany	-0.60%	-0.61%	-0.92%	-0.84%	-0.52%	-0.78%	0.62%	0.02%
Greece	-0.21%	-0.20%	-0.40%	-0.31%	-0.18%	-0.48%	0.62%	0.02%
Italy	-0.41%	-0.41%	-0.70%	-0.61%	-0.42%	-0.70%	0.62%	0.02%
Japan	-0.69%	-0.70%	-1.07%	-0.98%	-0.67%	-0.93%	0.62%	0.02%
Korea	-0.42%	-0.44%	-0.79%	-0.70%	-0.49%	-0.77%	0.62%	0.02%
Mexico	-0.42%	-0.30%	-0.51%	-0.42%	0.56%	-0.22%	0.62%	0.02%
New Zealand	-0.28%	-0.25%	-0.47%	-0.39%	-0.13%	-0.52%	0.62%	0.02%
Norway	-0.39%	-0.37%	-0.64%	-0.55%	-0.33%	-0.67%	0.62%	0.02%
Portugal	-0.25%	-0.24%	-0.46%	-0.38%	-0.22%	-0.51%	0.62%	0.02%
Spain	-0.36%	-0.36%	-0.59%	-0.50%	-0.30%	-0.58%	0.62%	0.02%
Sweden	-0.60%	-0.60%	-0.93%	-0.85%	-0.50%	-0.83%	0.62%	0.02%
Turkey	-0.23%	-0.22%	-0.41%	-0.32%	-0.11%	-0.40%	0.62%	0.02%
United Kingdom	-0.55%	-0.54%	-0.85%	-0.76%	-0.45%	-0.76%	0.62%	0.02%
United States	2.80%	3.08%	3.47%	3.56%	2.98%	1.70%	0.62%	0.02%

Tables 19h-k Effects of a 20% increase in the technology parameters of the U.S. Machinery industry

	h. Capital stock				i. Foreign investment into U.S. in the steady state as percentage of		
	No int'l investment		With int'l investment			U.S.	Foreign
	Impact	S.S.	Impact	S.S.		investment	investment
Australia	0.04%	0.48%	-1.10%	-0.44%	Australia	0.04%	1.90%
Austria	0.03%	0.29%	-1.28%	-0.63%	Austria	0.02%	1.12%
Canada	0.07%	0.83%	-0.68%	-0.02%	Canada	0.09%	4.51%
Finland	0.03%	0.32%	-1.19%	-0.53%	Finland	0.02%	0.96%
France	0.03%	0.30%	-1.25%	-0.59%	France	0.16%	8.23%
Germany	0.02%	0.26%	-1.41%	-0.75%	Germany	0.29%	14.84%
Greece	0.03%	0.35%	-0.90%	-0.24%	Greece	0.00%	0.24%
Italy	0.02%	0.30%	-1.26%	-0.60%	Italy	0.12%	6.04%
Japan	0.02%	0.25%	-1.61%	-0.96%	Japan	0.86%	43.35%
Korea	0.02%	0.28%	-1.41%	-0.75%	Korea	0.07%	3.73%
Mexico	0.09%	0.95%	-0.10%	0.56%	Mexico	0.01%	0.41%
New Zealand	0.04%	0.44%	-0.90%	-0.24%	New Zeal.	0.01%	0.25%
Norway	0.03%	0.38%	-1.14%	-0.48%	Norway	0.01%	0.65%
Portugal	0.03%	0.32%	-0.98%	-0.32%	Portugal	0.01%	0.29%
Spain	0.03%	0.30%	-1.08%	-0.43%	Spain	0.05%	2.58%
Sweden	0.03%	0.36%	-1.38%	-0.73%	Sweden	0.04%	1.94%
Turkey	0.03%	0.32%	-0.83%	-0.18%	Turkey	0.01%	0.48%
United Kingdom	0.03%	0.35%	-1.29%	-0.64%	U.K.	0.17%	8.48%
United States	0.15%	1.65%	3.12%	3.80%	Total	1.98%	100.00%

j. Total factor productivity change in the steady state, no international investment

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	-0.008	-0.005	-0.006	-0.006	-0.008	-0.006	-0.006	-0.002
Austria	-0.007	-0.005	-0.006	-0.005	-0.007	-0.006	-0.006	-0.004
Canada	-0.011	-0.009	-0.010	-0.010	-0.011	-0.010	-0.011	0.001
Finland	-0.007	-0.005	-0.005	-0.005	-0.006	-0.005	-0.005	-0.003
France	-0.007	-0.005	-0.006	-0.005	-0.007	-0.006	-0.006	-0.004
Germany	-0.009	-0.006	-0.007	-0.006	-0.008	-0.007	-0.007	-0.005
Greece	-0.005	-0.002	-0.003	-0.003	-0.004	-0.004	-0.003	-0.001
Italy	-0.007	-0.004	-0.005	-0.005	-0.006	-0.005	-0.005	-0.003
Japan	-0.010	-0.007	-0.009	-0.007	-0.009	-0.008	-0.008	-0.006
Korea	-0.008	-0.005	-0.008	-0.007	-0.008	-0.006	-0.006	-0.003
Mexico	-0.009	-0.009	-0.013	-0.010	-0.009	-0.007	-0.009	0.004
New Zealand	-0.006	-0.004	-0.005	-0.005	-0.006	-0.005	-0.004	-0.001
Norway	-0.007	-0.005	-0.005	-0.005	-0.007	-0.006	-0.006	-0.003
Portugal	-0.006	-0.002	-0.004	-0.004	-0.005	-0.004	-0.004	-0.001
Spain	-0.006	-0.004	-0.005	-0.004	-0.006	-0.005	-0.005	-0.002
Sweden	-0.009	-0.007	-0.007	-0.007	-0.008	-0.007	-0.008	-0.005
Turkey	-0.005	-0.003	-0.003	-0.003	-0.004	-0.003	-0.003	0.000
United Kingdom	-0.008	-0.006	-0.007	-0.006	-0.008	-0.007	-0.007	-0.004
United States	0.013	0.014	0.014	0.011	0.011	0.012	0.013	0.038

k. World effects

	No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.
Capital stock	0.07%	0.77%	0.17%	0.84%
Real manufacturing income	0.63%	0.72%	0.66%	0.75%
Interest rate	N/A	N/A	0.62%	0.02%