Determinants of specialization and the role of trade costs

Serge Shikher*

January 29, 2010

Abstract

The trade theory suggests that productivities, factor endowments, trade costs, and tastes determine the pattern of trade and specialization around the world. This paper empirically investigates the relative importance of these determinants by using the innovative general equilibrium model of trade that is distinguished by its use of the Eaton-Kortum methodology to explain intra-industry trade. Trade costs are shown to be the key determinant of trade and specialization. First and foremost, they reduce the geographical range of comparative advantage, forcing it to be determined within a neighborhood of a country instead of the whole world. Second, trade costs strongly link preferences with specialization. Third, because trade costs vary across industries, they affect comparative advantage by influencing the relative costs of goods of one country in another. Industry-level productivities and differences in tastes have the second- and third-largest effects on the pattern of trade and specialization. Factor endowments and firm-level productivities have the smallest effects. The paper also finds that the effects of various determinants of trade vary with country income. Most interestingly, the effect of factor endowments is much greater in the poorer countries than in the richer ones.

JEL codes: F1, F10

Keywords: trade costs, local comparative advantage, Ricardian comparative advantage, Heckscher-Ohlin, tastes, heterogeneous producers

1 Introduction

The modern trade theory suggests several determinants of trade and specialization. They include technology, factor endowments, trade costs, tastes, and returns to scale. Various theories exist that explain the effects of these determinants. Various empirical studies have been performed to check if these theories provide good explanations of the data.

There is evidence now that all of the above determinants of trade have a significant affect on the pattern of trade and specialization in production. It would be interesting then to somehow compare the importance of these determinants. Unfortunately, there is little theoretical guidance that can help us make this comparison.

To make this comparison empirically requires a model that incorporates all of these determinants of trade, and a methodology for measuring and comparing the importance of these determinants. This paper sets out to accomplish these tasks, with the exception of studying the effects of the returns to scale. It is hoped that the results presented in this paper will help us sort through the

*Assistant Professor, Suffolk University and Visiting Assistant Professor, Boston University. Email: sshikher@bu.edu.

various determinants of trade and specialization and contribute to our understanding of how these determinants create the currently observed patterns of specialization and trade.[1]

The model used in this paper includes constant returns to scale, fixed factor endowments that are different across countries, industry-level productivity differences, and taste differences across countries. It also incorporates trade costs that are different for each industry and each pair of countries. To explain the within-industry two-way trade between countries this paper allows for producer heterogeneity within industries using the framework of Eaton and Kortum.[2] The paper presents the evidence, both on the micro and macro levels, that supports this model.

The effects of various determinants of trade are studied by performing counterfactual simulations. The importance of the determinants is measured by the magnitudes of their effects on specialization and pattern of trade. The paper also checks if the importance of the determinants varies with country income.

Several interesting results emerge from the simulations. Trade cost emerge as the key determinant of the pattern of trade and specialization. They limit the geographical range of comparative advantage, forcing it to be determined within a neighborhood of a country instead of the whole world. Also, they vary across industries, thus directly affecting the relative costs of goods of one country in another. Finally, they strongly link preferences with specialization and net exports, signifying that the lack of attention paid to preferences in the trade literature is unwarranted.

After trade costs, industry-level productivity differences and differences in tastes have the second- and third-largest effects on the pattern of trade and specialization. Factor endowments and firm-level productivity differences have the smallest effects.

The paper also finds that all of the above determinants have a greater effect on trade and specialization in the poorer than richer countries. Interestingly, factor endowments stand out in this respect, because their influence is many times larger in the poorer countries than in the richer ones. Correspondingly, the effects of factor endowments on trade and specialization in the richer countries can be called economically insignificant. This result gives support to the notion that the Heckscher-Ohlin reason for trade is more relevant to the poorer than to the richer countries.

2 Determinants of trade and specialization

The determinants of trade and specialization exist on both the supply and demand sides. The supply-side determinants include productivity, factors of production, and trade costs.[3] On the demand side, the cross-country differences in preferences affect trade.

Of all the determinants of trade listed above, productivity and factor endowments have received the most attention in the trade literature. The effects of productivity differences on trade were modeled by Ricardo (1817), Dornbusch, Fischer and Samuelson (1977), and Eaton and Kortum (2002) and shown to be empirically important by MacDougall (1951), Trefler (1995), and Harrigan (1997). Productivity affects the pattern of trade and specialization because productivity differences between countries vary across industries and goods. This variation gives rise to comparative advantages, which in turn determine the pattern of trade and specialization.

[1] By the pattern of trade I mean "who sells what to whom", also known in the literature as the direction of trade.

[2] Other models that incorporate the framework of Eaton and Kortum (2002) are Shikher (2004b), Costinot and Komunjer (2006), and Chor (2009). The last paper is the most closely related to this one - it investigates the effects of various determinants of trade on country welfare.

[3] The returns to scale are also supply-side determinants of trade, but are not considered in this paper.

The effects of factor endowments were modeled by Heckscher (1919), Ohlin (1924), Samuelson (1949), Vanek (1968), and others. The empirical investigations of the effects of factor endowments are summarized in Leamer and Levinsohn (1995), Harrigan (1997), and Davis and Weinstein (2001). Factor endowments affect trade and specialization because they vary across countries and are used differentially across industries, giving rise to comparative advantages.

Trade costs have been empirically shown to be an important determinant of trade by the gravity literature. Anderson and van Wincoop (2004) summarize various types of trade costs and show how large they can be. The Dornbusch-Fischer-Samuelson and Eaton-Kortum models incorporate trade costs into their general equilibrium models of trade.

While the importance of trade costs for the overall volume of trade between countries has been demonstrated many times, their effects on the pattern of trade and specialization have been hardly investigated.

Trade costs affect the pattern of trade and specialization in several ways. The first way is more obvious: trade costs vary by industry, thus affecting the relative cost of country i's goods in country n and, therefore, the comparative advantage of country i (for both final and intermediate goods).[4] Another way is less obvious: trade costs shape comparative advantage even if they are equal across industries, by affecting the cost of intermediate goods. For example, about 15% of the intermediate goods used by the Machinery industry comes from the Metals industry. So, being "close" to a country that can produce Metals products cheaply is good for the domestic Machinery industry.

Yet another way in which trade costs affect the pattern of trade and specialization is discussed in Deardorff (2004) who calls it the "local comparative advantage". With trade costs, the pattern of trade is determined by the comparative advantage relative to the low-trade-cost ("neighboring") trade partners, not so much the high-trade-cost ("far away") countries.[5] In other words, trade costs decrease the geographic range of comparative advantage. Again, even if trade costs were equal across industries, they would still affect the pattern of trade.

Finally, trade costs affect the pattern of trade and specialization by linking production with tastes. The demand-side explanations of trade have received noticeably less attention than the supply-side explanations. Most trade models assume identical homothetic preferences. On the other hand, Linder (1961) observed that people with similar per-capita incomes have similar consumption patterns and that these patterns vary with the level of income. This of course implies nonhomothetic preferences. Markusen (1986) presents evidence for nonhomotheticity of demand and a model that incorporates nonhomothetic demand to explain the observed pattern of trade. In line with that evidence, the data used in this paper shows significant cross-country variation of industry shares in consumption.[6]

Because of trade costs, there is a strong relationship between tastes and specialization in production.[7] For most countries and industries, purchases by domestic customers constitute the largest use

[4] This effect of trade costs was analyzed by Venables and Limão (2002). The evidence that trade costs vary significantly by industry includes Hummels (2001), Anderson and van Wincoop (2004), and the calculations done in this paper.

[5] This effect cannot be modeled in the two-country Ricardian or Dornbusch-Fischer-Samuelson models.

[6] For example, Sweden spends 1% of its GDP on the final Textile products, while Austria spends 3%. Italy spends 10% of its GDP on the final Machinery products, while Japan spends 20%. There is also a relationship between the industry shares in consumption and income. Similar to other studies, for example, the share of the Food industry is negatively correlated with per capita income. See Markusen (1986) for evidence on the Food industry. Shares of some industries, such as Paper and Machinery, are positively correlated with per capita income in the data used in this paper.

[7] The correlation in the data between industry value added shares in GDP and industry consumption shares in

of output. Contrast this with the neoclassical trade model in which the production and consumption decisions are separate because countries can freely buy and sell goods on the world markets at a world price. In this case, a country would export according to its comparative advantage and import according to its preferences, resulting in relationship between preferences and net exports, but not between preferences and specialization in production.

3 Model

This section presents the model that will be used to investigate the importance of various determinants of trade. The model is formally described in Section 3.1 and the parametrization procedure is explained in Section 3.2.

The model is based on the neoclassical assumptions of multiple industries, constant returns to scale, perfectly competitive markets, and several factors that are mobile across industries. Each industry is characterized by a particular level of technology, set of factor intensities, and a demand function. Countries differ in their fixed factor endowments. In all of these aspects, the model is similar to the currently available computable models of trade.

However, while other models use the Armington assumption to explain the two-way trade between countries, this model relies on the Eaton-Kortum (EK) framework at the industry level. Within each industry, there is a continuum of goods produced with different productivities.

The use of the EK framework instead of the Armington (1969) approach has several important implications. The goods are differentiated by their features, not by their country of origin, so there is no need to estimate the elasticities of substitution between goods of different origins. The home bias in consumption and cross-country price differentials are explained by trade costs rather than demand-side parameters. The model has been shown to perform well in counterfactual simulations, as described in Section 3.3.

3.1 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. There are two factors of production: capital and labor. The industry cost function has the Cobb-Douglas form:

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

where r_i is the return to capital, w_i is the wage, ρ_{ij} is the price of intermediate inputs, $\alpha_j > 0$ is the capital share, $\beta_j > 0$ is the labor share, and $1-\alpha_j-\beta_j > 0$ is the share of intermediate inputs. It is assumed 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, $\eta_{jm} > 0$ is the share of industry m goods in the input of industry j, such that $\sum_{m=1}^{J} \eta_{jm} = 1$, $\forall j$.

GDP is 0.85.

Intra-industry production, trade, and prices are modeled following Eaton and Kortum (2002). In each industry, there is a continuum of goods, with each good indexed on the interval $[0,1]$ by l and produced with its own productivity. Productivities $z_{nj}(l)$ are the result of the R&D process and probabilistic, drawn independently from the Fréchet distribution with cdf $F_{ij}(z) = e^{-T_{ij}z^{-\theta}}$, where $T_{ij} > 0$ and $\theta > 1$ are the parameters.[8] Consumers have CES preferences over the continuum of goods within an industry with the elasticity of substitution $\sigma > 0$.

The price of good l of industry j produced in country i and delivered to country n is $p_{nij}(l) = c_{ij}d_{nij}/z_{ij}(l)$, where d_{nij} is the Samuelson's "iceberg" transportation cost of delivering industry j goods from country i to country n.[9] In country n, consumers buy from the lowest-cost supplier, so the price of good l in country n is $p_{nj}(l) = \min\{p_{nij}(l), i = 1, ..., N\}$.

The distribution (cdf) of prices p_{nij} is $G_{nij}(p) = 1 - F_{ij}(c_{ij}d_{nij}/p) = 1 - e^{-T_{ij}(c_{ij}d_{nij})^{-\theta}p^{\theta}}$. The distribution of p_{nj} is $G_{nj}(p) = 1 - \prod_{i=1}^{N}[1 - G_{nij}(p)] = 1 - e^{-\Phi_{nj}p^{\theta}}$, where $\Phi_{nj} = \sum_{i=1}^{N} T_{ij}(c_{ij}d_{nij})^{-\theta}$ summarizes technology, input costs, and transport costs around the world. The exact price index for the within-industry CES objective function is then $p_{nj} = \left[\int_0^1 p_{nj}(l)^{1-\sigma}dl\right]^{1/(1-\sigma)} = \left[\int_0^{\infty} p_{nj}^{1-\sigma}dG_{nj}(p)\right]^{1/(1-\sigma)} = E\left[P_{nj}^{1-\sigma}\right]^{1/(1-\sigma)} = \gamma\Phi_{nj}^{-1/\theta}$, where $\gamma \equiv \Gamma((\theta + 1 - \sigma)/\theta)^{1/(1-\sigma)}$ and Γ is the Gamma function.[10] This price index can also be written as

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

where γ is a constant. Plugging this price index into (1), the cost equation becomes

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

To derive the industry-level bilateral trade flows, we note that the probability that a producer from country i has the lowest price in country n for good l is $\pi_{nij} \equiv \Pr[p_{nij}(l) \leqslant \min\{p_{nsj}(l); s \neq i\}] = \int_0^{\infty}\prod_{s\neq i}[1 - G_{nsj}(p)]\,dG_{nij}(p) = T_{ij}(\gamma c_{ij}d_{nij}/p_{nj})^{-\theta}$. Since there is a continuum of goods on the interval $[0,1]$, this probability is also the fraction of industry j goods that country n buys from i. It is also the fraction of n's expenditure spent on industry j goods from i or X_{nij}/X_{nj} (this is true because conditional on the fact that country i actually supplies a particular good, the distribution of the price of this good is the same regardless of the source i). So, the industry-level bilateral trade is given by

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

where X_{nij} is the spending of country n on industry j goods produced in country i and X_{nj} is the total spending in country n on industry j goods.

[8] Kortum (1997) and Eaton and Kortum (1999) provide microfoundations for this approach. Parameter T_{ij} governs the mean of the distribution, while parameter θ, which is common to all countries and industries, governs the variance. The support of the Fréchet distribution is $(0,\infty)$.

[9] To receive \$1 of product in country n requires sending $d_{nij} \geqslant 1$ dollars of product from country i. By definition, domestic transport costs are set to one: $d_{nnj} \equiv 1$. Trade barriers result in $d_{nij} > 1$.

[10] The last equality is obtained by setting $x = -\ln p$, $t = \sigma - 1$, and noting that the moment-generating function for x is $E\left[e^{tx}\right] = \Phi^{t/\theta}\Gamma(1 - t/\theta)$ ((Johnson and Kotz, 1970)).

Parameter T governs the average productivity of producers in an industry. Therefore, it determines comparative advantage across industries. For example, country n has a comparative advantage in industry j if $T_{nj}/T_{nm} > T_{ij}/T_{im}$.[11] Parameter θ determines the comparative advantage across goods within an industry. Lower value of θ means more dispersion of productivities among producers, leading to stronger forces of within-industry comparative advantage.

Industry output Q_{ij} is determined as follows. The goods market clearing equation is

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

where Z_{nj} and C_{nj} are amounts spent by country n on industry j's intermediate and consumption goods, respectively. The spending on intermediate goods is $Z_{nj} = \sum_m \eta_{mj} w_n L_{nm} \left(1 - \alpha_m - \beta_m\right)/\alpha_{gm}$, where L_{nm} is the stock of labor employed in industry m of country n.[12]

Consumer preferences are two-tier: Cobb-Douglas across industries and, as previously mentioned, CES across goods within each industry. Therefore, $C_{nj} = \psi_{nj} Y_n$, where Y_n is the total income (GDP) in country n and $\psi_{nj} \geqslant 0$ is a parameter of the model that determines tastes.[13] Plugging the expressions for intermediate and consumption spending into (6), the output equation becomes

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} \left(\left(\sum_{m=1}^{J} \frac{\eta_{mj} \left(1 - \alpha_m - \beta_m\right)}{\beta_m} w_n L_{nm} \right) + \psi_{nj} Y_n \right). \tag{7}$$

Since production is Cobb-Douglas, industry factor employments are given by $K_{ij} = \alpha_j Q_{ij}/r_i$ and $L_{ij} = \beta_j Q_{ij}/w_i$. Factors of production can be freely and instantaneously moved across industries within a country, subject to the constraints $\sum_{j=1}^{J} K_{ij} = K_i$ and $\sum_{j=1}^{J} L_{ij} = L_i$, where K_i and L_i are the factor stocks, which are fixed.

Due to data limitations, only the manufacturing industries are included in the J industries. The nonmanufacturing sector's price index is normalized to 1 and its purchases of the manufacturing intermediates are treated as final consumption. Country income Y_i is the sum of the manufacturing income Y_i^M and nonmanufacturing income Y_i^O:

$$Y_i = Y_i^M + Y_i^O = w_i L_i + r_i K_i + Y_i^O, \tag{8}$$

where factor stocks K_i and L_i are specific to manufacturing. Following Dekle, Eaton and Kortum (2007) and Alvarez and Lucas (2007), the manufacturing is assumed to be a constant proportion of the GDP, so that $Y_i^O = \xi_i Y_i$, where $\xi_i \geqslant 0$ is a parameter of the model.

The model is given by equations (3)-(5), (7)-(8), and the four factor employment and factor clearing equations. Model parameters are α_j, β_j, η_{jm}, θ, ψ_{nj}, d_{nij}, T_{nj}, K_i, L_i, and ξ_i. The model solves for all other variables including all prices, industry factor employments, output, and trade.[14]

[11] The productivity parameter T is different from the total factor productivity (TFP). Parameter T determines the mean of the Fréchet distribution and is exogenous in this model. TFP, on the other hand, is endogenous. Finicelli, Pagano and Sbracia (2007) derive the analytic relationship between the T of an industry and the mean productivity of the firms that actually operate in that industry. Similarly to TFP, though, T is potentially affected by technology as well as social and political factors.

[12] It obtains as follows: $Z_{nj} = \sum_m Z_{nmj} = \sum_m p_{nj} M_{nmj} = \sum_m \eta_{mj} \rho_{nm} M_{nm}$, where Z_{nmj} is the amount spent by industry m on intermediate goods from industry j, M is the quantity of intermediate goods, and the last equality follows from (2). Then from (1) $\rho_{nm} M_{nm} = w_n L_{nm} \left(1 - \alpha_m - \beta_m\right)/\alpha_{gm}$.

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

[14] The model has $N^2 J + 5NJ + 3N$ unknowns and the same number of equations. The unknowns in the model are

3.2 Assigning parameter values

The model is parametrized using 1989 data for 8 two-digit manufacturing industries in 19 OECD countries.[15] The included countries and industries can be seen in Table 1.

The values of shares α_j, β_j, and η_{jm} are taken from the data.[16] Table D1 shows the differences in factor intensities across industries. The most capital-intensive industry, Chemicals, uses nearly twice as much capital stock (for the same amount of value added) as the least capital-intensive industry, Textile. These differences in factor intensities, when combined with the differences in factor endowments across countries, determine specialization. For example, a country with a low capital-labor ratio will specialize in Textiles, while a country with a high capital-labor ratio will specialize in Chemicals.

The value of the technology parameter θ is taken from Eaton and Kortum (2002) where it is estimated to be 8.28. This value is within the range of the long-term trade elasticity estimates in the literature ((Ruhl, 2008)).[17]

Estimation of the trade costs is discussed in Section 3.2.1. The values for parameters ψ_{nj}, d_{nij}, T_{nj}, K_i, L_i, and ξ_i are obtained by fitting a subset of the model to data, which is described in Section 3.2.2.

3.2.1 Trade barriers

Bilateral trade barriers are estimated by applying the approach of Eaton and Kortum (2002) at the industry level. The ratio of n's spending on i's goods to its spending on its domestically-made goods is obtained from equation (5):

$$\frac{\pi_{nij}}{\pi_{nnj}} = \frac{X_{nij}}{X_{nnj}} = \frac{T_{ij}}{T_{nj}} d_{nij}^{-\theta} \left(\frac{c_{ij}}{c_{nj}} \right)^{-\theta}. \tag{9}$$

To relate the unobservable trade cost to the observable country-pair characteristics, the following trade cost function is used:

$$\log d_{nij} = d_{kj}^{phys} + b_j + l_j + f_j + m_{nj} + \delta_{nij}, \tag{10}$$

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

X_{nij}, c_{nj}, p_{nj}, K_{nj}, L_{nj}, Q_{nj}, Y_n, w_n, and r_n.

[15] The year and countries are chosen because of the availability of data.

[16] Labor shares in output are from the UNIDO. I use the average labor shares of the countries in the sample. Capital shares in output are obtained using ratios of capital to labor shares from the dataset described in Shikher (2004a), which carefully calculates capital shares in several countries. I multiply the labor shares by these ratios to obtain capital shares. I do not use the value added data from the UNIDO to obtain capital shares because that data are unreliable. Industry shares η_{jm} are obtained from the OECD input-output tables. These tables exist only for some of the countries in the dataset and only for select years. I use the input-output tables for Canada, France, Germany, Japan, U.K., and the U.S. for 1990, and Australia for 1989. Input-output tables for these countries result in very similar shares η_{jm}. I use the average shares across these countries.

[17] The other value of θ estimated by Eaton and Kortum (2002), 3.6, is too low even by their own admission and is outside of the range of values found in the literature. In any case, Shikher (2008a) found that the choice of θ in the range $[3.6, 13]$ has little effect on how factor endowments and technology affect specialization (the differences in results were second- or third-order).

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.

Then, the gravity-like estimating equation is obtained by taking logs of both sides of (9):

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta d_{kj}^{phys} - \theta b_j - \theta l_j - \theta f_j + D_{ij}^{exp} + D_{nj}^{imp} - \theta \delta_{nij}, \tag{11}$$

where $D_{ij}^{exp} = T_{ij} c_{ij}^{-\theta}$ is the exporter dummy, $D_{nj}^{imp} = -\theta m_{nj} - \log T_{nj} c_{nj}^{-\theta}$ is the importer dummy.[18]

Bilateral trade data needed to estimate equation (11) is from Feenstra (1997) and Feenstra (2000).[19] 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 (11) are obtained as follows. I 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, I divide distance into 6 intervals: [0,375), [375,750), [750,1500), [1500,3000), [3000,6000), and [6000,maximum). I 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.

The average (across country pairs and industries) estimated transport cost is 2.27. This transport cost includes all costs necessary to move goods between countries, such as freight, insurance, tariffs, non-tariff barriers, and theft in transit. Trade costs vary across country pairs and industries. For example, the Machinery and Textile products are typically cheaper to move between countries than the Wood and Food products.

Table D2 summarizes the estimated trade costs d_{nij}. Their magnitude is substantial: about 2.3 (equivalent to a 130% tariff) for a typical industry and a typical pair of countries. Trade costs also vary across industries: Textile and Machinery products are, on average, cheaper to ship than Wood or Paper products.

3.2.2 Technology and other fitted parameters

The parameters ψ_{nj}, d_{nij}, T_{nj}, K_i, L_i, and ξ_i are obtained by fitting a subset of the model, together with a long-run equilibrium condition, to domestic data.[20] The subset of the model includes the cost equation (4), reproduced here:

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \prod_{m=1}^{J} \left[\gamma^{-\theta} \sum_{n=1}^{N} T_{nm} \left(d_{inm} c_{nm} \right)^{-\theta} \right]^{-\frac{\eta_{jm}\left(1-\alpha_j-\beta_j\right)}{\theta}}, \tag{12}$$

[18] Note that the estimating equation includes the export and import dummy variables, similarly to the theoretically-derived gravity equation of Anderson and van Wincoop (2003).

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

[20] This procedure is different from the approach used by Eaton and Kortum (2002) to find the technology parameters. They calculate technology parameters from the estimated importer and exporter dummies and data on wages.

where r_i is the interest rate and w_i is the wage, as well as a simplified version of the output equation (7):

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} X_{nj}, \tag{13}$$

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

Equations (12)-(13) can be solved simultaneously for the technology parameters T_{nm} and costs c_{ij} given data on the rates of return r_i, wages w_i, output Q_{ij}, spending X_{nj}, and the estimated transport costs d_{nij}. However, data on the rates of return r_i is not available, so their values in the base year are approximated at 20%.[21]

The values of the technology parameters T_i are hard to interpret. On the other hand, the mean productivities are easier to understand. The mean productivity in industry j of country i is equal to $E[z_{ij}] = T_{ij}^{1/\theta}\Gamma(1 - 1/\theta)$, where Γ is the Gamma function. The mean productivity in industry j of country i relative to the mean productivity of industry j in the United States is then $(T_{ij}/T_{US,j})^{1/\theta}$.

Table D3 presents the relative mean productivities for each country and industry. These mean productivities determine the industry-level Ricardian comparative advantage, which influences the pattern of trade and specialization. For example, relative to the United States, Japan is shown to have the strongest comparative advantage in Nonmetals and Machinery products and the strongest comparative disadvantage in Food and Wood products.[22]

The industry employments of capital and labor are calculated as $K_{ij} = \alpha_j Q_{ij}/r_i$ and $L_{ij} = \beta_j Q_{ij}/w_i$.[23] The country factor stocks K_i and L_i are calculated as the sum of industry factor employments. The last column of Table D3 shows the capital-labor ratios in different countries, relative to the United States, $(K_i/L_i)/(K_{US}/L_{US})$. It shows, for example, that Turkey has only about 9% of the capital per worker that the United States has. The differences of factor endowments across countries, when combined with the differences of factor intensities across industries, shown in Table D1, determine the Heckscher-Ohlin comparative advantage, which in turn influences the pattern of trade and specialization.

Nonmanufacturing share ξ_i is calculated as $1-(r_iK_i + w_iL_i)/Y_i$, where the total income (GDP) Y_i is taken from data. The taste parameters are calculated as $\psi_{ij} = C_{ij}/Y_i$, where the consumption is calculated as $C_{ij} = X_{ij} - Z_{ij} = X_{ij} - \sum_{m=1}^{J} \eta_{mj}(1 - \alpha_{km} - \alpha_{lm}) Q_{im}$. The taste parameters are shown in Table D4. As mentioned in the introduction, there are significant differences in consumption preferences across countries, which affect the pattern of specialization and trade. For example, while Turkey spends a somewhat higher fraction of its income on Food and Textile products than Japan, it spends a much smaller fraction of its income on Paper and Machinery

[21] The rates of return r_i are gross rates. The rate of 20% is obtained by assuming 10% net return and 10% depreciation. The results presented in the paper are not sensitive to these values.

[22] The table also shows that there are differences in mean productivities across countries. For example, the mean productivity draw in Mexico is about a half of that in the United States. However, it should be remembered that with trade, the average productivity of firms actually operating is higher than the mean productivity draw, because goods with low productivity draws are not produced, but imported. The average productivity in a country does not influence the pattern of trade or specialization, but influences the country welfare.

[23] These industry factor employments may not be exactly equal to the actual ones because of the assumptions of equal factor shares across countries and equal rates of return across industries. We can check how close they are by assembling the data for industry capital and labor employments. I take the industry labor employments from the UNIDO and calculate the industry capital employments by applying the perpetual inventory method to the investment time series from the UNIDO. The correlation between the two measures of industry-level capital employments is 0.99. The same number for labor employments is 0.97.

products. In another example, France, Germany, Italy, and the U.K spend about 2% of their income on Textile products, while Sweden, Norway, and Finland spend 1-1.4%.

3.3 Evaluating the model

Since the above model will be used to study properties of the international trade, it is important to evaluate it.[24] There are several approaches to evaluating a model. One is to fit the model to data and evaluate the fit. In case of the model of this paper, it is possible to compare the trade flows implied by the model with the actual trade flows.[25] The correlation between the predicted and actual trade flows is 0.99. It is similar if calculated by industry or by country.

Though these numbers show an extremely good fit, one needs to keep in mind that the model has many degrees of freedom and, therefore, can fit the in-sample data well. A more challenging evaluation for the model would be to ask it to make predictions outside of the sample used to parametrize it.

Such exercises were performed in Shikher (2008a) and Shikher (2008b). The first paper evaluated the ability of the model to predict changes in specialization, measured by industry shares in GDP, in response to changes in capital stock. This was accomplished by asking the model to predict the changes in specialization that occurred during 1975-95. The model was parametrized with 1989 data, so the model had to make a backcast for 1988-75 and a forecast for 1990-95. In order to make the predictions, the model was fed the data on changes in country capital stocks during 1975-95. All the other parameters were unchanged from their 1989 values.

The accuracy of the predictions was evaluated by (a) regressing the actual changes in specialization on the predicted ones and (b) by comparing the semielasticities of specialization with respect to capital in the actual and simulated data. The estimated slope of the regression in (a) was not significantly different from one and the semielasticities in the actual and simulated data in (b) were very similar.

The second paper, also a historical experiment, evaluated the ability of the model to predict changes in trade due to the trade liberalization in North America. The model was parametrized with 1989 data and asked to predict the changes in industry-level trade flows between the U.S., Canada, and Mexico that would occur due to NAFTA. In order to make these predictions, the model was given the magnitudes of the 1989 policy-related trade barriers (tariffs and non-tariff barriers) that were to be removed under NAFTA. All other parameters were unchanged from their 1989 values.[26]

The accuracy of the forecasts was evaluated by comparing (a) the predicted changes in total exports and imports of the NAFTA countries with the actual ones that occurred between 1989 and 2000 and (b) the predicted and actual (1989-2000) changes in the industry-level import shares.[27] The correlation between the simulated and actual changes in the exports and imports was found to be 0.95. The correlation between the simulated and actual changes in the import shares for

[24] The evidence for the microfoundations of the model - heterogeneity of productivity across producers within the same industry - is numerous now and reviewed in Eaton, Kortum and Kramarz (2004).

[25] As mentioned earlier, the bilateral trade data is from Feenstra (1997) and Feenstra (2000). The trade flows predicted by the model are the values of $X_{nij} = \pi_{nij} X_{nj} = T_{ij} \left(\gamma c_{ij} d_{nij} / p_{nj} \right)^{-\theta} X_{nj}$, calculated given the parameter values described in Section 3.2.

[26] Tariffs and NTBs are part of total trade costs d. Therefore, removing tariffs τ means reducing d by τ.

[27] An industry-level import share is the share of country i in the industry j imports of country n.

the U.S.-Canada and U.S.-Mexico trade was found to be 0.95.[28] The slope and intercept from the regression of the actual on simulated changes were not significantly different from one and zero, respectively.

While these two studies do not provide an exhaustive evaluation of the model, they provide solid evidence that the predictions of the model can be believed.

4 Relative importance of the determinants of trade

The model allows us to study the effects that the current levels of factor endowments, productivity, trade costs, and tastes have on the pattern of trade and specialization. As mentioned before, by the pattern of trade I mean "who sells what to whom", which is also called the direction of trade. The pattern of trade can be measured by net exports. Specialization in production, also known as industrial structure, is usually measured by industry shares in GDP.

The pattern of trade and specialization are related, as a country that specializes in a particular industry tends to export more of that industry' goods. However, in a world with intermediate goods, trade costs, and taste differences this relationship need not be tight. For example, a country separated from others by high trade barriers and with a strong preference for a particular good will produce more of that good, but will not necessarily export more of it.[29]

More formally, net exports are $NE_{nj} = EX_{nj} - IM_{nj}$ while specialization is measured by $S_{nj} = VA_{nj}/VA_n$. An important difference between S_{nj} and NE_{nj} is that the former is measured in value added terms while the latter is measured in output terms. Another important difference is that industry shares are measured relative to other industries while net exports are not. One consequence of this last difference is that net exports will increase with general economic growth, while industry shares will not.

Seven counterfactual simulations will be performed in order to find out how the current levels of factor endowments, technology, trade costs, and tastes affect the pattern of trade and specialization. Each of these simulations will remove the effect of one of these determinants and note the consequences of this removal for the pattern of trade and specialization. The determinants will be studied one-by-one, so that when the effect of one the determinants is removed, the effects of all other determinants still remain.

Factor endowments affect trade and specialization because (a) they are different across countries and (b) factor intensities are different across industries.[30] Therefore, the effects of factor endowments can be found by either (a) removing factor endowment differences across countries or (b) removing factor intensity differences across industries. Both approaches will be used. The simulation #1 will set $K_n^{new} = \left(\overline{K/L}\right) L_n$, where $\overline{K/L}$ is some common capital-labor ratio, while the simulation #2 will set $\alpha_j^{new} = \bar{\alpha}\left(\alpha_j + \beta_j\right)$, $\beta_j^{new} = (1-\bar{\alpha})\left(\alpha_j + \beta_j\right)$, where $\bar{\alpha} = (1/J)\sum_j \alpha_j / \left(\alpha_j + \beta_j\right)$.[31]

There are two kinds of the productivity differences in the model that can affect trade and

[28] U.S.-Canada and U.S.-Mexico trade constitute more than 99% of the North American trade. The Canada-Mexico trade is hard to evaluate because of data irregularities in several industries.

[29] On the other hand, in a world of small countries and free trade the production and consumption decisions can be made separately.

[30] To review the factor endowments and intensities in the data, see Section 3.2 and Tables D1 and D3.

[31] The level of the common capital-labor ratio has no effect on the results. The average factor intensity $\bar{\alpha}$, as well as the other averages calculated in this section, can be weighted or unweighted. The effects of various weighing schemes on the results are minor. Their small size does not justify their presentation in the paper.

specialization. One is at the industry-level. Since the cross-country differences in productivities vary across industries, there are industry-level comparative advantages.[32] For example, country n has a comparative advantage in industry j if $T_{nj}/T_{ij} > T_{nm}/T_{im}$. The effect of these comparative advantages can be found by eliminating them, i.e. setting T_{nj}/T_{ij} to be the same in all industries.

At the same time, we want to preserve the absolute advantage that country n may have over country i. This country-level absolute advantage τ_{ni} is measured as the average of industry-level absolute advantages: $\tau_{ni} = (1/J)\sum_j T_{nj}/T_{ij}$. So, we want to set T_{nj}/T_{ij} to be the same in all industries, while keeping τ_{ni} constant. This is accomplished by setting $T_{nj}^{new} = \tau_{ni}T_{ij}$, $\forall j$. The simulation #3 will use the United States as the reference country i and will set $T_{nj}^{new} = (T_{US,j}/J)\sum_j T_{nj}/T_{US,j}$ in every country n other than the U.S.

The second kind of the productivity differences in the model exists at the firm level. Within the same industry, there are differences of productivities across producers. The dispersion of these productivities is governed by the parameter θ. To find the effect of these productivity differences on the pattern of trade and specialization, the simulation #4 will eliminate them by setting a very high value of θ, thereby making all producers within an industry virtually identical in terms of productivity.[33] Increasing θ decreases intra-industry trade and results in nearly complete specialization corner solutions.

Tastes in the model are determined by parameters ψ_{nj}. To eliminate the effect of taste differences on trade and specialization, the simulation #5 will set these parameters equal in all countries, i.e. set $\psi_{nj}^{new} = \psi_j$, $\forall n$, where $\psi_j = (1/N)\sum_n \psi_{nj}$.

As mentioned earlier, trade costs affect the pattern of trade and specialization in several ways. First, trade costs help determine the comparative advantage because they vary across industries and country pairs and, therefore, affect the relative cost of one country's goods in another. To eliminate this effect of trade costs on the pattern of trade and specialization the simulation #6 will set the trade costs equal across industries for each pair of countries. In other words, it will set $d_{nij}^{new} = (1/J)\sum_j d_{nij}$.

Second, trade costs shape the patter of trade and specialization by affecting the costs of intermediate goods. Being "close" to a cheap source of intermediate goods can benefit industries that use these intermediate goods. Third, trade costs make the determination of comparative advantage "local". With trade costs, the nearby countries have a much greater impact in the determination of comparative advantage than do far-away countries. Greater trade costs decrease the size of the "neighborhood" within which the comparative advantage is determined. To eliminate these last two effects of trade costs, the simulation #7 will set all trade costs d_{nij} to one, i.e. set all international trade to be free.

The fourth way in which trade costs affects trade and specialization is by firmly linking together preferences in consumption and specialization in production. Setting all trade costs to one will also help eliminate this effect of trade costs.

The seven simulations described above will permit us to quantify the effects of factor endowments, productivity, tastes, and trade costs on the pattern of trade and specialization. We will measure these effects by the percent changes in net exports and industry shares relative to their baseline values. To summarize the percent changes, which are expected to vary across industries and countries, several statistics will be shown for each simulation. The minimum and maximum (across all industries and countries) values of the percent changes will show the range of changes.

[32] To review the industry-level productivity differences across countries in the data, see Section 3.2.2 and Table D3.

[33] In practice, it is increased to 99. It is the maximum value for which a numerical solution can be obtained.

The averages (across all industries and countries) of the absolute values of the percent changes will show the average magnitudes of the changes.[34] These average magnitudes will be used to compare the importance of various determinants of trade. A determinant, whose removal causes the highest average absolute percent change in net exports and/or specialization, will be deemed the most important for the pattern of trade and/or specialization.

4.1 Results

Tables R1 and R2 summarize the results of the simulations. Each simulation entails the removal of the determinant of trade listed in the first column. The second column shows the average (across countries and industries) of the absolute values of the percent changes in industry shares (Table R1) and net exports (Table R2). As mentioned earlier, these average absolute percent changes are used to compare the importance of various determinants of trade for the pattern of trade and specialization.

The third column shows the rank (1 through 7) of each determinant of trade according to the average absolute percent change in industry shares or net exports that its removal causes. Based on the previous discussion, higher ranked determinants are deemed more important than the lower ranked ones. The rankings based on these two criteria are similar (correlation is 0.71) and the differences in the rankings are never greater than two positions. The last two columns show the range of the percent changes in industry shares and net exports.

The results show that of all the determinants of trade considered in this paper, trade costs have the greatest effect on the current pattern of trade and specialization. As previously discussed, trade costs affect trade and specialization in several ways: by altering the relative costs of delivered goods, affecting the costs of intermediate goods, decreasing the geographic range of comparative advantage, and linking preferences with production. The results of the simulation #7 show that removing all trade costs causes the average industry share to change (increase or decrease) by more than a third and causes the average industry net exports to change 11-fold. The changes can be very dramatic: some industries virtually disappear, while others see their shares grow several fold. Net exports can increase many times over and/or change signs.[35]

The results of the simulation #6 show that the differences in trade costs across industries have a moderate effect on the pattern of trade and specialization. They are ranked fifth in terms of their effect on industry shares and third in terms of their effect on net exports.

Industry-level productivity differences, which determine Ricardian comparative advantages, are ranked second most-important determinant of trade and specialization. The results of the simulation #3 show that removing these differences causes the average industry share to change by a third and the average industry net exports to change 4-fold.

Preferences are found to have moderate effects on trade and specialization. They are ranked third in terms of their effect on industry shares and fifth in terms of their effect on net exports. The results of the simulation #5 show that removing taste differences across countries causes the average industry share to change by 20% and net exports by 158%. The effects of preferences are certainly not so small so as to justify the scant attention they get in the trade literature. The effects

[34] The average of absolute percent changes is a good measure because we are interested in the magnitude of the effect, not its direction. The average of percent changes is not a good measure because the negative changes will offset the positive changes resulting in average changes close to zero.

[35] Net exports can change by a large negative percentage (as in column 5 of Table R2) if they change sign during a simulation.

of preferences on specialization and trade are about 1/2 to 2/3 of the effects of the industry-level productivity comparative advantages.

Firm-level productivity differences have a relatively small effect on trade and specialization, ranking fourth and sixths in terms of their effect on industry shares and net exports, respectively. Removing these differences in the simulation #4 causes the average industry share to change by 18.5% and net exports by 97%.

Finally, the effects of factor endowments on trade and specialization were found to be small. Simulation #1 measured the effect of factor endowments by removing factor endowment differences across countries. The results show that removing these differences causes the average industry share to change only by 4.8% and net exports by 175%. These changes are ranked sixth and fourth, respectively.

Simulation #2 measured the effect of factor endowments by removing factor intensity differences across industries. Removing these differences caused the average industry share to change by a very small 3.9% and net exports by 58%. Both of these changes are ranked seventh, smallest of all. Therefore, factor endowments are found to be much less influential than productivity in determining the pattern of trade and specialization. Section 4.1.2 has something interesting to add to the factor endowment story.

4.1.1 More on trade costs

As mentioned earlier, trade costs affect the pattern of trade and specialization by, among other things, reducing the geographic range of comparative advantages and linking preferences with production. To further investigate these effects of trade costs, simulations #1-3, and #5 are repeated with trade costs set to one (i.e. with free trade). The results are presented in Table R3. It shows the average absolute percent changes in industry shares and net exports that occur when the simulations are performed with the current levels of trade costs and free trade.

Results of the simulations #1-3 show that the factor endowment- and productivity-based comparative advantages become more influential when trade costs are removed. With the current level of trade costs, removing industry-level productivity differences causes the average industry share to change by 30.8% and net exports by 329%. With free trade, these numbers are about three times as big: 102% and 808%, respectively.

Without trade costs, a country's comparative advantages are determined in the whole world, not just its "neighborhood". Without trade costs, countries serve more destinations according to their comparative advantages. As the result, countries become more specialized. One way to see this increased specialization is by looking at the Grubel-Lloyd (GL) intra-industry trade index. The bilateral GL index is widely used to measure the prevalence of intra-industry trade between two countries. Given by $G_{nij} = 2\min\left(X_{nij} + X_{inj}\right) / \left(X_{nij} + X_{inj}\right)$, where X_{nij} is the amount of industry j imports that n receives from i, it is equal to zero if all trade is inter-industry and one if all trade is intra-industry. The world GL index is the average of all bilateral GL indices in all industries: $G = (1/J)\left(1/\left(N^2 - N\right)\right)\sum_{n \neq i}\sum_j G_{nij}$.

The GL index in the baseline model is 0.44.[36] With the current levels of trade costs, removing industry-level productivity differences (as in the simulation #3) increases the GL index to by 0.044. So, introducing industry-level comparative advantages increases inter-industry trade, as expected. More inter-industry trade means that countries are more specialized.

[36] For comparison, it is 0.45 in the trade data.

Repeating the simulation #3 with all trade costs set to one, we find that removing industry-level productivity differences increases the GL index by 0.12. Therefore, industry-level comparative advantages cause more specialization with free trade than with the current level of trade costs.

Factor endowments also become more influential with free trade, according to most measures, but not as much as the industry-level productivity differences. The effects of factor endowment differences and factor intensity differences on industry shares are about 1.5 times greater with trade trade. Their effects on net exports are mixed: factor intensity differences have a greater effect with free trade, but factor endowment differences have less. Their effects on the GL index are very small.

Lastly, we investigate the relationship between trade costs and the effects of preferences on the pattern of trade and specialization. Trade costs link domestic production with preferences. With free trade, on the other hand, the production and consumption decisions are made separately.

Repeating simulation #5 with free trade shows this effect. Removing trade costs increases the separation between production and consumption decisions, thus decreasing the effect of tastes on specialization (from 20 to 10%) and increasing their effect on net exports (from 158 to 1091%).[37]

4.1.2 Richer vs. poorer countries

It is interesting to check if the effects of the determinants of trade analyzed in this paper vary with country income. In order to do it, we will divide the countries in the dataset into two groups. One group will include all the countries that had 1989 GDP per capita less than half of the U.S.'s. This group will include Greece, Korea, Mexico, Portugal, Spain, Turkey, and will be called the middle-income group. The second group, that includes all the other countries, will be called the high-income group.

Table R4 shows the average absolute percent changes in the industry shares and net exports of all countries (repeated from the first columns of Tables R1 and R2), middle-income countries, and high-income countries. The last column shows the ratio of the middle-income countries' to high-income countries' averages. Higher ratio means greater difference in the effect of a particular determinant of trade on the poorer vs. richer countries.[38]

The results clearly show that the greatest difference between the poor and richer countries is in the effects of factor endowments and factor intensities. Their effects in the middle-income countries are 3.5 to 7.9 times greater than in the high-income countries. This supports the notion that the Heckscher-Ohlin reason for trade is more applicable to poorer than to richer countries.[39] In the high-income counties, the influence of factor endowments is much weaker than the influence of other determinants of trade. Their effects on specialization are in fact small enough to have little economic significance.[40]

Other determinants of trade also tend to be more influential in the poorer than in richer countries. The effects of industry-level productivity differences and preferences are about 1.6-2 times

[37] The effect of preferences on specialization is not zero even with the free trade because countries are "large", i.e. able to influence their terms of trade.

[38] Note that all the numbers in each row of Table R4 come from the same simulation, i.e. the numbers for the richer and poorer countries come from the same experiment.

[39] Given greater relative importance of factor endowments and factor intensities in the middle-income than in the high-income countries, it is sensible to expect their relative importance to be even greater in the low-income countries.

[40] Out of 104 industries (8 industries in 13 countries) only 12 change their industry shares by more than 5% and only one changes it by more than 10% if factor endowment differences are removed. If factor share differences are removed, only 1 out of 104 industries changes its share by more than 5% and none by more than 10%.

greater in the middle-income than in the high-income countries. The effects of trade costs and firm-level productivity are about 1-1.5 times greater in the middle-income countries.

The differences in importance of various determinants of trade between the richer and poorer counties results in several differences in their rankings. For example, the industry-level productivity differences, not trade costs, are the most important determinant of specialization in the poorer countries. The factor endowment and factor intensity differences are ranked higher in the poorer than richer countries in terms of their importance for the pattern of trade. They are still ranked last in the both sets of countries, however, in terms of their importance for specialization.

5 Conclusion

The paper investigates the importance of technology, factor endowments, trade costs, and preferences for the pattern of trade and specialization. It starts by reviewing the mechanisms through which these determinants of trade affect trade and specialization. It then presents a model that incorporates all of these determinants of trade and can be used to gauge their importance.

The effects of various determinants of trade are studied by performing counterfactual simulations of the model, which is parametrized using 1989 data for 19 OECD countries. Evidence is presented to support the ability of the model to make accurate predictions. The importance of the determinants is measured by the magnitudes of their effects on specialization and pattern of trade.

The results show the great importance of trade costs. While previous literature has demonstrated their importance for the volume of trade, this paper shows how significant they are for the specialization and pattern of trade. Trade costs decrease the range of comparative advantage forces, in effect making them local rather than global. Trade costs affect relative prices of intermediate inputs and final goods, and link domestic production with domestic preferences.

Productivity differences and differences in tastes also have significant effects on the pattern of trade and specialization. By most measures, factor endowments are found to be the least influential determinant of trade for the average country in the dataset. One of the important implications of these results is that any analysis of specialization and trade must include trade costs and preferences in addition to the traditional duopoly of technology and factor endowments.

The paper also finds that the impacts of the determinants of trade vary with country income. Most of the determinants of trade are more influential in the poorer countries, but the factor endowments especially so. Their effects in the poorer countries are many times greater than in the richer ones. In the richer countries, however, their effects are small enough to be called economically insignificant. This result supports the notion that the Heckscher-Ohlin reason for trade is more applicable to the poorer countries than the richer ones.

References

Alvarez, F. and Lucas, R. E. (2007). General equilibrium analysis of the Eaton-Kortum model of international trade, *Journal of Monetary Economics* **54**: 1726–1768.

Anderson, J. E. and van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle, *American Economic Review* **93**(1).

Anderson, J. E. 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.

Chor, D. (2009). Unpacking sources of comparative advantage: A quantitative approach, *Manuscript, Singapore Management University* .

Costinot, A. and Komunjer, I. (2006). What goods do countries trade? New Ricardian predictions, *Manuscript, University of California at San Diego* .

Davis, D. R. and Weinstein, D. E. (2001). An account of global factor trade, *The American Economic Review* **91**(5): 1423–1453.

Deardorff, A. V. (2004). Local comparative advantage: Trade costs and the pattern of trade, *RSIE Discussion Paper No. 500* .

Dekle, R., Eaton, J. and Kortum, S. (2007). Unbalanced trade, *American Economic Review* **97**(2): 351–355.

Dornbusch, R., Fischer, S. and Samuelson, P. (1977). Comparative advantage, trade, and payments in a Ricardian model with a continuum of goods, *American Economic Review* **67**: 823–839.

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

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

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

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* .

Finicelli, A., Pagano, P. and Sbracia, M. (2007). Trade-revealed TFP, *Manuscript, Bank of Italy* .

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

Heckscher, E. (1919). The effects of foreign trade on the distribution of income, *Ekonomisk Tidskrift* **21**: 497–512.

Hummels, D. (2001). Toward a geography of trade costs, *Manuscript, Purdue University* .

Johnson, N. L. and Kotz, S. (1970). *Continuous Univariate Distributions*, Houghton and Mifflin.

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.

Linder, S. (1961). *An Essay on Trade and Transformation*, Almqvist and Wiksell, Uppsala.

MacDougall, G. D. A. (1951). British and american exports: A study suggested by the theory of comparative costs, *The Economic Journal* **61**(244).

Markusen, J. R. (1986). Explaining the volume of trade: An eclectic approach, *The American Economic Review* **76**(5).

Ohlin, B. (1924). *Handelns Teori*, AB Nordiska Bokhandeln.

Ricardo, D. (1817). *The Principles of Political Economy and Taxation*, John Murray, London.

Ruhl, K. (2008). The international elasticity puzzle, *Manuscript, University of Texas* .

Samuelson, P. A. (1949). International factor-price equalization once again, *The Economic Journal* **59**(234).

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, *Manuscript, Suffolk University* .

Shikher, S. (2004b). Putting industries into the Eaton-Kortum model, *Manuscript, Suffolk University* .

Shikher, S. (2008a). Capital, technology, and specialization in the neoclassical model, *Manuscript, Suffolk University* .

Shikher, S. (2008b). Predicting the effects of NAFTA: Now we can do it better!, *Manuscript, Suffolk University* .

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.

Vanek, J. (1968). The factor proportions theory: The n-factor case, *Kyklos* **21**: 749–754.

Venables, A. J. and Limão, N. (2002). Geographical disadvantage: A Heckscher-Ohlin-von Thünen model of international specialization, *Journal of International Economics* **58**: 239–263.

Table D1 Shares of factors and intermediate inputs in output

Industry	Capital (α_j)	Labor (β_j)	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

*The share of intermediate inputs is ($1-\alpha_j-\beta_j$).
**The share of capital in value added is $\alpha_j/(\alpha_j+\beta_j)$.

Table D2 Trade costs

	Tariff equivalent of trade cost
Food*	146.7%
Textile*	106.9%
Wood*	159.4%
Paper*	146.9%
Chemicals	123.7%
Nonmetals	139.1%
Metals*	109.8%
Machinery	104.7%
Average**	129.6%
Maximum*	566.4%
Minimum**	0.0%
St. Dev.**	76.8%

*Average for all country pairs
**Of all country pairs and industries

Table D3 Technology parameters and capital-labor ratios, relative to the United States

	Scaled and normalized technology parameters $(T_i/T_{US})^{1/\theta}$								Capital-labor ratios*
	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery	
Australia	0.85	0.76	0.61	0.68	0.69	0.69	0.90	0.70	0.52
Austria	0.65	0.80	0.65	0.74	0.72	0.82	0.79	0.73	0.60
Canada	0.85	0.86	0.92	0.97	0.80	0.79	0.99	0.79	0.80
Finland	0.59	0.74	0.75	0.90	0.71	0.69	0.84	0.73	0.64
France	0.89	0.96	0.79	0.85	0.89	0.97	0.94	0.87	0.92
Germany	0.83	0.95	0.83	0.88	0.92	0.99	0.96	0.92	0.89
Greece	0.68	0.69	0.45	0.49	0.56	0.66	0.68	0.48	0.20
Italy	0.81	1.04	0.88	0.83	0.85	1.04	0.89	0.88	0.88
Japan	0.74	0.97	0.77	0.87	0.93	1.05	1.00	1.03	0.98
Korea	0.66	0.87	0.56	0.61	0.72	0.68	0.79	0.71	0.26
Mexico	0.57	0.56	0.42	0.45	0.61	0.57	0.63	0.50	0.12
New Zeal.	0.88	0.71	0.62	0.68	0.66	0.57	0.71	0.60	0.38
Norway	0.76	0.66	0.66	0.78	0.74	0.67	0.87	0.70	0.68
Portugal	0.62	0.65	0.51	0.58	0.54	0.64	0.58	0.51	0.17
Spain	0.77	0.79	0.64	0.71	0.74	0.83	0.82	0.69	0.43
Sweden	0.66	0.72	0.73	0.85	0.75	0.75	0.85	0.79	0.64
Turkey	0.59	0.62	0.39	0.37	0.55	0.60	0.65	0.43	0.09
U.K.	0.84	0.87	0.70	0.81	0.85	0.88	0.88	0.82	0.62
U.S.	1	1	1	1	1	1	1	1	1

*These ratios are calculated as $(K_i/L_i)/(K_{US}/L_{US})$

Table D4 Consumption shares in income

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	0.058	0.018	0.017	0.022	0.028	0.016	0.027	0.123
Austria	0.073	0.030	0.024	0.020	0.044	0.024	0.021	0.158
Canada	0.064	0.018	0.014	0.016	0.040	0.010	0.006	0.157
Finland	0.080	0.014	0.022	0.040	0.028	0.015	0.021	0.130
France	0.070	0.022	0.012	0.022	0.046	0.013	0.014	0.157
Germany	0.065	0.021	0.013	0.012	0.061	0.012	0.001	0.175
Greece	0.094	0.036	0.011	0.012	0.071	0.021	0.036	0.116
Italy	0.048	0.019	0.007	0.012	0.030	0.011	0.026	0.103
Japan	0.067	0.019	0.014	0.025	0.038	0.017	0.008	0.199
Korea	0.082	0.021	0.011	0.019	0.105	0.029	0.033	0.239
Mexico	0.045	0.009	0.001	0.009	0.039	0.009	0.031	0.092
New Zeal.	0.085	0.024	0.018	0.031	0.031	0.012	0.007	0.139
Norway	0.080	0.013	0.021	0.030	0.017	0.008	0.007	0.134
Portugal	0.101	0.013	0.016	0.014	0.085	0.024	0.024	0.167
Spain	0.097	0.022	0.015	0.016	0.051	0.020	0.021	0.141
Sweden	0.060	0.010	0.022	0.022	0.025	0.009	0.012	0.141
Turkey	0.071	0.024	0.003	0.003	0.093	0.021	0.049	0.079
U.K.	0.074	0.021	0.016	0.033	0.050	0.018	0.013	0.170
U.S.	0.058	0.016	0.011	0.028	0.044	0.008	0.008	0.146

Table R1 Percent changes of industry shares in value added

Sim. #	Simulation*	Av. of abs.**	Rank	Minimum	Maximum
1.	Factor endowments	4.76	6	-23.29	46.30
2.	Factor shares	3.88	7	-30.71	27.93
3.	Industry productivity	30.86	2	-72.80	459.10
4.	Firm-level productivity	18.49	4	-99.95	88.44
5.	Preferences	20.15	3	-45.77	243.35
6.	Relative trade costs	14.30	5	-84.35	86.04
7.	All trade costs	36.88	1	-95.60	196.58

*Each simulation removes a particular determinant of trade
**The average of the absolute percent changes

Table R2 Percent changes of net exports

Sim. #	Simulation*	Av. of abs.**	Rank	Minimum	Maximum
1.	Factor endowments	175.29	4	-1,739.19	8,154.17
2.	Factor shares	58.04	7	-356.57	1,552.99
3.	Industry productivity	329.22	2	-3,588.33	3,678.06
4.	Firm-level productivity	97.39	6	-256.77	157.72
5.	Preferences	158.05	5	-2,450.00	990.27
6.	Relative trade costs	258.85	3	-3,030.44	3,915.09
7.	All trade costs	1,001.76	1	-11,713.80	20,910.00

*Each simulation removes a particular determinant of trade
**The average of the absolute percent changes

Table R3 Effects of trade costs

		Effects on industry shares**		Effects on net exports**	
Sim. #	Simulation*	With current trade costs	With free trade	With current trade costs	With free trade
1.	Factor endowments	4.76	6.11	175.29	109.51
2.	Factor shares	3.88	7.42	58.04	91.68
3.	Industry productivity	30.86	102.27	329.22	808.45
5.	Preferences	20.15	9.98	158.05	1091.34

*Each simulation removes a particular determinant of trade
**The numbers are the averages of the absolute percent changes

Table R4 Poorer vs. richer countries

A. Effects on industry shares*

Sim. #	Simulation**	All	Poorer***	Richer***	Poorer/Richer
1.	Factor endowments	4.76	9.28	2.67	3.47
2.	Factor shares	3.88	9.23	1.41	6.53
3.	Industry productivity	30.86	45.41	24.14	1.88
4.	Firm-level productivity	18.49	22.94	16.44	1.40
5.	Preferences	20.15	29.41	15.88	1.85
6.	Relative trade costs	14.30	17.40	12.88	1.35
7.	All trade costs	36.88	37.77	36.46	1.04

*The numbers are the averages of the absolute percent changes
**Each simulation refers to removal of a particular determinant of trade
***Poorer countries are those with 1989 GDP/capita less than 1/2 of the U.S.'s, richer are all others

B. Effects on net exports*

Sim. #	Simulation**	All	Poorer***	Richer***	Poorer/Richer
1.	Factor endowments	175.29	435.48	55.21	7.89
2.	Factor shares	58.04	123.88	27.65	4.48
3.	Industry productivity	329.22	445.76	275.44	1.62
4.	Firm-level productivity	97.39	93.61	99.13	0.94
5.	Preferences	158.05	240.08	120.18	2.00
6.	Relative trade costs	258.85	324.45	228.58	1.42
7.	All trade costs	1,001.76	1,317.32	856.12	1.54

*The numbers are the averages of the absolute percent changes
**Each simulation refers to removal of a particular determinant of trade
***Poorer countries are those with 1989 GDP/capita less than 1/2 of the U.S.'s, richer are all others