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DETERMINANTS OF TRADE AND SPECIALIZATION IN THE ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT COUNTRIES

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This paper empirically investigates the relative importance of productivity, factor endowments, trade costs, and tastes in determining the current pattern of trade and specialization. The results show that productivity and taste differences are the first and second most significant determinants of trade and specialization. Factor endowments are the least influential for the average country in the data set, but their effects are much greater in the poorer than richer countries. The results also show the substantial role of trade costs, which is amplified through interactions with other determinants of trade. Trade costs affect the relative costs of intermediate inputs and final goods, link preferences with specialization, and reduce the geographical range of comparative advantages. (*JEL* F1, F10)

I. INTRODUCTION

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 and a number of 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 effect 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. The results presented in this paper will help us sort through the 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

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1. By the pattern of trade I mean "who sells what to whom," also known in the literature as the direction of trade.
2. The model is parametrized using 1989 data for 19 countries; a paper that also uses the framework of Eaton and Kortum (2002) and is related to this one is Chor (2010)—it investigates the effects of various determinants of trade on country welfare.

ABBREVIATIONS

CES: Constant Elasticity of Substitution
GDP: Gross Domestic Product
GL: Grubel-Lloyd
NAFTA: North American Free Trade Agreement
OECD: Organisation for Economic Co-operation and Development
TFP: Total Factor Productivity
UNIDO: United Nations Industrial Development Organization

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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 and shows the effects of various determinants of trade on welfare.

Simulations produce several interesting results. Productivity differences across countries and industries are found to be the most influential determinants of trade and specialization. Preferences are found to be second most influential, signifying that the lack of attention paid to them in the trade literature is unwarranted. At the same time, factor endowments are found to be the least influential in the average country of the data set.

Trade costs are found to be very important determinants of trade and specialization. While previous literature has demonstrated their importance for the volume of trade, this paper shows how significant they are for specialization and the pattern of trade. The trade costs' direct effects on trade, which occur because trade costs differ across countries and industries, is found to be moderate. However, trade costs' indirect effect, whereby they interact with other determinants of trade, is very significant. For example, trade costs strongly link preferences with specialization and net exports. They also influence trade by affecting access to intermediate goods. In addition, trade costs limit the geographical range of comparative advantage, forcing it to be determined within a neighborhood of a country instead of the whole world.

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

II. 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 differences across countries give rise to absolute advantages. Comparative advantages exist because productivity differences between countries vary across industries and goods.

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.

Although 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

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

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.

are equal across industries, by affecting the cost of intermediate goods. For example, about 15% of the intermediate goods used by the machinery industry come from the metals industry. So, being "close" to a country that can produce metal 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, with most trade models assuming 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. Fieler (forthcoming) incorporates nonhomothetic preferences into the Eaton and Kortum (2002) model. In line with previous evidence, the data used in this paper show 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 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.

III. 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 III.A and the parametrization procedure is explained in Section III.B. The model has been previously shown to perform well in counterfactual simulations, as described in Section III.C.

The model uses 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.

To explain the two-way trade between countries, this model relies on the Eaton and Kortum's (2002) framework at the industry level. Within each industry, there is a continuum of goods produced with different productivities. These productivity differences mean that the two-way trade will consist of different sets of goods being traded each way.

The use of the Eaton–Kortum framework instead of the Armington (1969) approach has several important implications. The goods are differentiated by their features, not their country of origin. Countries do not have monopoly power over their products. The home bias in consumption and cross-country price differentials are explained by trade costs rather than demand-side parameters.

A. Description of the Model

There are N countries and J industries in each country. Subscripts i and n refer to countries, whereas subscripts j and m refer to industries. There are two factors of production: capital and labor.

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

6. For example, Sweden spends 1% of its gross domestic product (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 GDP is 0.85.

Intra-industry production, trade, and prices are modeled following Eaton and Kortum (2002). Each industry produces many goods. Within an industry, each good is indexed by a real number l on the interval [0, 1] and produced using a Cobb–Douglas production process. Factor shares are the same for all goods within an industry, but different across industries. Total factor productivities are different across goods l within each industry. The total factor productivity of producing good l in industry j of country i is $z_{ij}(l)$.

The description of these productivities is the key element of the Eaton–Kortum model. It is assumed that productivities $z_{ij}(l)$ are the result of the R&D process, which is random. Therefore, the productivities $z_{ij}(l)$ are random. They are independent realizations of the random variable Z_{ij}, which has the Fréchet distribution with cdf $F_{ij}(z) = e^{-T_{ij}z^{-\theta}}$, where $T_{ij} > 0$ and $\theta > 1$ are the parameters.[8]

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 $T_{nj}/T_{nm} > T_{ij}/T_{im}$.[9] 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.

The cost of producing one unit of good l of industry j produced in country i is $c_{ij}/z_{ij}(l)$. In that equation, c_{ij} is the industry cost function and is given by

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

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:

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

In this expression, $\eta_{jm} > 0$ is the share of industry m goods in the input of industry j, such that $\sum_{m=1}^{J} \eta_{jm} = 1, \forall j$.

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.[10] Since $z_{ij}(l)$ is a realization of a random variable, $p_{nij}(l)$ is also a realization of a random variable (let's call it P_{nij}). The cdf of P_{nij} is $G_{nij}(p) = \Pr\left(P_{nij} \le p\right) = \Pr\left(c_{ij}d_{nij}/Z_{ij} \le p\right) = \Pr\left(c_{ij}d_{nij}/p \le Z_{ij}\right) = 1 - F_{ij}\left(c_{ij}d_{nij}/p\right) = 1 - e^{-T_{ij}\left(c_{ij}d_{nij}\right)^{-\theta}p^{\theta}}$.

In country n, consumers buy from the lowest-cost supplier, so the price of good l in country n is $p_{nj}(l) = \min\left\{p_{nij}(l), i = 1, \ldots, N\right\}$, which is a realization of a random variable P_{nj}. The distribution of P_{nj} is $G_{nj}(p) = \Pr(P_{nj} \le p) = 1 - \Pr(P_{nj} > p) = 1 - \Pr(P_{nij} > p, \forall i) = 1 - \prod_{i=1}^{N}[1 - G_{nij}(p)] = 1 - e^{-\Phi_{nj}p^{\theta}}$, where $\Phi_{nj} = \sum_{i=1}^{N} T_{ij}(c_{ij}d_{nij})^{-\theta}$ summarizes technology, input costs, and transport costs around the world.

On the demand side, consumers have nested two-tier preferences. They have Cobb–Douglas preferences over industries, with industry j in country n having a share ψ_{nj} (so that $\sum_j \psi_{nj} = 1$). Consumers have constant elasticity of substitution (CES) preferences over the goods within an industry with the elasticity of substitution $\sigma > 0$.

The exact price index for the within-industry CES objective function is denoted by p_{nj} and can be calculated as

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 $(0, \infty)$. The use of the Fréchet distribution is motivated as follows. There are many R&D labs that develop new technologies for good l. The productivities of these new technologies are drawn from the Pareto distribution (which is a good distribution to describe the situation where you have few good outcomes and many mediocre or bad ones). With perfect competition, the technologies are public knowledge, so only the most productive technology for making good l will be used by producers. The productivity of this technology is the maximum of the Pareto draws, which is described by the extreme value type II (also known as Fréchet) distribution.

9. 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 (2009) derive the analytic relationship between the T of an industry and the mean productivity of the firms that actually operate in that industry. Similar to TFP, though, T is potentially affected by technology as well as social and political factors.

10. 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 $d_{nij} > 1$.

(3)
$$p_{nj} = \left[\int_0^1 p_{nj}(l)^{1-\sigma} dl\right]^{1/(1-\sigma)} = \left[\int_0^\infty p_{nj}^{1-\sigma} dG_{nj}(p)\right]^{1/(1-\sigma)}$$
$$= E\left[P_{nj}^{1-\sigma}\right]^{1/(1-\sigma)} = \gamma\left[\sum_{i=1}^N T_{ij}\left(c_{ij}d_{nij}\right)^{-\theta}\right]^{-1/\theta} = \gamma\Phi_{nj}^{-1/\theta},$$

where $\gamma \equiv \Gamma\left(\left(\theta + 1 - \sigma\right)/\theta\right)^{1/(1-\sigma)}$ and Γ is the Gamma function.[11] Plugging this price index into Equation (1), the cost equation becomes

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

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 $\pi_{nij} \equiv \Pr\left[p_{nij}(l) \leq \min\left\{p_{nsj}(l); s \neq i\right\}\right] = \int_0^\infty \prod_{s\neq i}\left[1 - G_{nsj}(p)\right] dG_{nij}(p) = T_{ij}\left(\gamma c_{ij}d_{nij}/p_{nj}\right)^{-\theta}$. 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

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

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.

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

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

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

As consumers have Cobb–Douglas preferences across industries, $C_{nj} = \psi_{nj}Y_n$, where Y_n is the total income (GDP) in country n and ψ_{nj} is the share of industry j in country n, as previously defined.[13] Parameters ψ_{nj} determine tastes. Plugging the expressions for intermediate and consumption spending into Equation (6), the output equation becomes

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

Since production is Cobb–Douglas, industry factor employments are given by $K_{ij} = \alpha_jQ_{ij}/r_i$ and $L_{ij} = \beta_jQ_{ij}/w_i$. 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.

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

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 Equation (2). Then from (1) $\rho_{nm}M_{nm} = w_nL_{nm}\left(1 - \alpha_m - \beta_m\right)/\beta_m$.

13. Consumption C includes private consumption and government consumption.

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.[14] Country income Y_i is the sum of the manufacturing income Y_i^M and nonmanufacturing income Y_i^O:

$$(8) \qquad Y_i = Y_i^M + Y_i^O = w_i L_i + r_i K_i + Y_i^O,$$

where factor stocks K_i and L_i are specific to manufacturing. The model assumes that capital and labor are not mobile between the manufacturing and nonmanufacturing sectors. However, this specification is also consistent with factor mobility between manufacturing and nonmanufacturing if the factors are used in the same proportions in the two sectors. The nonmanufacturing income 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.[15]

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 such as all prices (including factor prices), industry factor employments, output, and trade.[16]

B. Assigning Parameter Values

The model is parametrized using 1989 data for 8 two-digit manufacturing industries in 19 OECD countries. The included countries and industries can be seen in Table 3.

The values of shares α_j, β_j, and η_{jm} are taken from the data.[17] Table 1 shows the differences in factor intensities across industries.

TABLE 1
Shares of Factors and Intermediate Inputs in Output

Industry	**Capital (α_j)**	**Labor (β_j)**	**Inputs[a]**	**Cap. in VA[b]**
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

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

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, whereas 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).[18]

Estimation of the trade costs is discussed in the first subsection of III.B. The values for parameters ψ_{nj}, d_{nij}, T_{nj}, L_i, and ξ_i are obtained by fitting a subset of the model to data, which is described in the second subsection of III.B.

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

14. Following Eaton and Kortum (2002), it is assumed that (at least some of) nonmanufacturing output can be traded costlessly and used as the numeraire.

15. Note that the nonmanufacturing share in income ξ_i is generally not equal to the nonmanufacturing share in consumption $\psi_{i,nonmanuf}$.

16. The model has $N^2 J + 5NJ + 3N$ unknowns and the same number of equations. The unknowns in the model are X_{nij}, c_{nj}, p_{nj}, K_{nj}, L_{nj}, Q_{nj}, Y_n, w_n, and r_n.

17. 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 data set described in Shikher (2004), 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 data set and only for select years. I use the input–output tables for Canada, France, Germany, Japan, United Kingdom, and the United States 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.

18. 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 (2011) 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). This paper also finds the results to be robust to the choice of θ.

from Equation (5):

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

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

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

where d_{kj}^{phys} $(k = 1, \ldots, 6)$ 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 an unobserved component of bilateral trade costs.

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

$$\text{(11)}\quad \log X_{nij}/X_{nnj} = -\theta d_{kj}^{phys} - \theta b_j - \theta l_j - \theta f_j + D_{ij}^{exp} + D_{nj}^{imp} - \theta\delta_{nij},$$

where $D_{ij}^{exp} = \log T_{ij} c_{ij}^{-\theta}$ is the exporter dummy, $D_{nj}^{imp} = -\theta m_{nj} - \log T_{nj} c_{nj}^{-\theta}$ is the importer dummy.[19] The destination-industry specific import barriers are calculated as $m_{nj} = -(1/\theta)$ $(D_{nj}^{exp} + D_{nj}^{imp})$.

Bilateral trade data needed to estimate Equation (11) is from Feenstra (1997) and Feenstra (2000).[20] 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 Eaton and Kortum (2002), I divide distance into six 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.

TABLE 2
Trade Costs

	Tariff Equivalent of Trade Cost
Food[a]	146.7%
Textile[a]	106.9%
Wood[a]	159.4%
Paper[a]	146.9%
Chemicals[a]	123.7%
Nonmetals[a]	139.1%
Metals[a]	109.8%
Machinery[a]	104.7%
Average[b]	129.6%
Maximum[b]	566.4%
Minimum[b]	0.0%
SD[b]	76.8%

[a]Average for all country pairs.
[b]Of all country pairs and industries.

Table 2 summarizes the estimated trade costs d_{nij}. Their magnitude is substantial: the average (across country pairs and industries) estimated trade cost is 2.29 (equivalent to a 129% tariff).[21] This trade 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.

Technology and Other Fitted Parameters. The parameters ψ_{nj}, d_{nij}, T_{nj}, L_i, and ξ_i are obtained by fitting a subset of the model, together with a long-run equilibrium condition, to domestic

19. 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).

20. 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 $19 \times 18 \times 8 = 2,736$ 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.

21. This number is greater than the 74% rich country international trade cost estimated in Anderson and van Wincoop (2004). There are several reasons for the difference: (1) the lowest-trade cost industry (Machinery) is by far the largest industry and (2) the sample of this paper includes a number of poor countries that have significantly higher trade costs than the rich countries. For example, the average trade cost for importing to the United States is 51% while to Turkey it is 231%.

data.[22] The subset of the model includes the cost equation (4), reproduced here:

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

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) and (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}.[23] However, data on the rates of return r_i are not available, so their values in the base year are calculated from the data on manufacturing capital stocks K_i, industry output Q_{ij}, and industry capital shares α_j using the relationship $r_i = (1/K_i) \sum_j \left(\alpha_j Q_{ij}\right)$.[24]

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 $E\left[z_{ij}\right] = T_{ij}^{1/\theta} \Gamma\left(1 - 1/\theta\right)$, 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 $\left(T_{ij}/T_{US,j}\right)^{1/\theta}$.

Table 3 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.[25]

The industry employments of capital and labor are calculated as $K_{ij} = \alpha_j Q_{ij}/r_i$ and $L_{ij} = \beta_j Q_{ij}/w_i$.[26] The manufacturing labor stocks L_i are calculated as the sum of industry factor employments. The last column of Table 3 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 12% of the capital per worker that the United States has.[27] The differences of factor endowments across countries, when combined with the differences of factor intensities across industries, shown in Table 1, determine the Heckscher–Ohlin comparative advantage, which in turn influences the pattern of trade and specialization.

22. 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.

23. The system of equations is solved numerically using Matlab. Convergence takes only a couple of minutes on a moderately speedy computer, given a set of reasonable starting values.

24. Labor compensation data is from the UNIDO's statistical database. As mentioned earlier, output data is also from the UNIDO's statistical database. Spending X_{nj} is obtained as output minus exports plus imports (trade data is from Feenstra (1997) and Feenstra (2000)). The manufacturing capital stocks K_i are calculated by applying the perpetual inventory method to the investment time series from the UNIDO. The calculated average rates of return r_i are around 20%, plus or minus a couple of percentage points (these are gross rates, so 20% can be explained roughly as a 10% net return and 10% depreciation rate). To check the robustness of the results to a measure of r_i, two alternative measures of r_i are used: (a) constant 20% for all countries and (b) from Caselli and Feyrer (2007). In (b), that paper's reported best measure of the net return to capital is used together with the assumption of a 10% depreciation rate to calculate the gross rates of return. These gross rates also turn out to be very close to 20% (even though Caselli and Feyrer 2007 measure the return to capital for the whole economy while r_i is the return to capital in manufacturing). Using any of the three measures of r_i produces substantially the same simulation results.

25. 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.

26. 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.

27. Relative to the United States, the K/L in many developing countries has declined during the 1980s ("the lost decade").

TABLE 3
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[a]
	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery	
Australia	0.84	0.76	0.61	0.68	0.68	0.69	0.89	0.70	0.53
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	0.56	0.55	0.42	0.45	0.60	0.57	0.62	0.50	0.13
New Zealand	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	0.57	0.61	0.38	0.35	0.53	0.58	0.63	0.42	0.12
United Kingdom	0.84	0.87	0.70	0.81	0.85	0.88	0.88	0.82	0.62
United States	1	1	1	1	1	1	1	1	1

[a]These ratios are calculated as $(K_i/L_i)/(K_{US}/L_{US})$.

Nonmanufacturing share (in income) 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 for the manufacturing industries are shown in Table 4. 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 products. In another example, France, Germany, Italy, and the United Kingdom spend about 2% of their income on Textile products, while Sweden, Norway, and Finland spend 1%–1.4%.

C. Evaluating the Model

As the above model will be used to study properties of the international trade, it is important to evaluate it.[28] 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.[29] The correlation between the predicted and actual trade flows is 0.99. It is similar if calculated by industry or by country.

Although these numbers show an extremely good fit, it is necessary 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 (2011) and Shikher (forthcoming). 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

28. 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).

29. 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 III.B.

TABLE 4
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 Zealand	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
United Kingdom	0.074	0.021	0.016	0.033	0.050	0.018	0.013	0.170
United States	0.058	0.016	0.011	0.028	0.044	0.008	0.008	0.146

Note: The remaining fraction of income in each country goes toward the nonmanufacturing goods.

asking the model to predict the changes in specialization that occurred during 1975–1995. The model was parametrized with 1989 data, so the model had to make a backcast for 1988–1975 and a forecast for 1990–1995. In order to make the predictions, the model was fed the data on changes in country capital stocks during 1975–1995. 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 United States, 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.[30]

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.[31] 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 the U.S.–Canada and U.S.–Mexico trade was found to be 0.95.[32] The slope and intercept from the regression of the actual on simulated changes were not significantly different from 1 and 0, respectively.

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

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

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

32. 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.

IV. 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 earlier, 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 exports, imports, and 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's 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.[33]

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} on one hand and EX_{nj}, IM_{nj}, and NE_{nj} on the other is that the former is measured in value-added (net) terms while the latter three are measured in output (gross) terms. Another important difference is that industry shares are measured relative to other industries while exports, imports, and net exports are not. One consequence of this last difference is that exports, imports, and net exports will increase with general economic growth, while industry shares will not.

Twelve 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.[34] The determinants will be studied one by one, so that when the effect of one of 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. 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. Simulation #1 will set $\alpha_j^{new} = \overline{\alpha}\left(\alpha_j + \beta_j\right)$, $\beta_j^{new} = (1 - \overline{\alpha})\left(\alpha_j + \beta_j\right)$, where $\overline{\alpha} = (1/J) \sum_j \alpha_j / \left(\alpha_j + \beta_j\right)$, while Simulation #2 will set $K_n^{new} = \left(\overline{K/L}\right) L_n$, where $\overline{K/L}$ is some common capital-labor ratio.[35]

There are two kinds of the productivity differences in the model that can affect trade and specialization. One is at the industry level. Since the cross-country differences in productivities vary across industries, there are industry-level comparative advantages.[36] 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, that is 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 $T_{nj}^{new} = \tau_{ni} T_{ij}$, $\forall j$. Simulation #3 will use the United States as the reference country i and will set $T_{nj}^{new} = \left(T_{US,j}/J\right) \sum_j T_{nj}/T_{US,j}$ in every country n other than the United States.

Simulation #4, on the other hand, will study the effects of eliminating cross-country differences in productivities (i.e., absolute advantages) on specialization and trade. This simulation will set $T_{nj}^{new} = (1/N) \sum_n T_{nj}$, $\forall j$.

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

34. Numerical simulations are done in Matlab. Convergence (using Matlab's "dogleg" algorithm) takes only a few minutes on a moderately speedy computer. There are a couple of simulations where the algorithm does not converge. In those cases, an intermediate solution (i.e., with parameter changes equal to the half of the desired changes) is found first and then used as a starting point to find the final solution.

35. The level of the common capital-labor ratio has no effect on the results. The average factor intensity $\overline{\alpha}$, 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.

36. To review the industry-level productivity differences across countries in the data, see the second subsection of III.B and Table 3.

The second kind of the productivity differences in the model exists at the producer 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, Simulation #5 will eliminate them by setting a very high value of θ, thereby making all producers within an industry virtually identical in terms of productivity.[37] Note that Simulation #5 is different from the other simulations performed in the paper because it does not set a parameter to its in-sample average. This is done because the only way to shut down the producer-level productivity differences is to set θ to a very high value.[38]

Setting a very high θ eliminates the much-more-productive-than-average producers that normally engage in exports. There will still be trade, of course, because all other determinants of trade (such as industry-level productivity differences) still remain. However, 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 effects of taste differences on trade and specialization, Simulation #6 will set these parameters equal in all industries (i.e., set $\psi_{nj}^{\text{new}} = \psi_n, \forall j$, where $\psi_n = (1/J)\sum_j \psi_{nj}$), while Simulation #7 will set them 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 for each country pair 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, Simulation #8 will set the trade costs equal across industries for each pair of countries. In other words, it will set $d_{nij}^{\text{new}} = (1/J)\sum_j d_{nij}$.

Second, trade costs affect the pattern of trade and specialization because some countries are more "remote" (from other countries) than others. To eliminate this effect of trade costs, Simulation #9 will make all countries equidistant from each other, while preserving the cross-industry differences in trade costs. In other words, trade costs will be set to their cross-country pair in-sample averages: $d_{nij}^{\text{new}} = \left(1/\left(N^2 - N\right)\right)\sum_{n \neq i}\sum_i d_{nij}$.

Third, trade costs shape the pattern 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. To gauge this effect of trade costs, Simulation #10 will set trade costs equal in all industries (as in Simulation #8) and will also eliminate the cross-industry variation in dependence on intermediates by setting $1 - \alpha_j - \beta_j$ and η_{jm} to their in-sample average values.

Fourth, 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 gauge this effect of trade costs, Simulation #11 will remove both cross-country and cross-industry differences, so that countries do not face any advantage in regards to geographical proximity.

The fifth way in which trade costs affects trade and specialization is by firmly linking together preferences in consumption and specialization in production. To gauge this effect of trade costs, Simulation #12 will set trade costs equal in all industries (as in Simulation #8) and set taste parameters ψ_{nj} equal to their cross-industry average values.

The 12 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. The simulations, except for Simulation #5 (as mentioned before), will gauge the effects of these determinants of trade by setting the values of specific parameters equal to their in-sample average values. We will measure the effects of each determinant of trade by the percent changes in industry shares, exports, imports, and net exports relative to their baseline values. The statistic that will be used to summarize these percent changes, which are expected to vary across industries and countries, is the average (across all industries and countries) of the absolute

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

38. In addition, of course, parameter θ is the same in all countries and industries.

TABLE 5
Percent Changes of Industry Shares in Value Added and Net Exports

			Industry Shares				Net Exports			
Sim. #	Simulation[a]	Variation removed[b]	Av. of Abs.[c]	Rank	Minimum	Maximum	Av. of Abs.[c]	Rank	Minimum	Maximum
1.	Factor shares	Cross-industry	3.88	12	−30.71	27.93	58.04	12	−356.57	1552.99
2.	Factor endowments	Cross-country	4.76	11	−23.29	46.30	175.29	7	−1739.19	8154.17
3.	Industry productivity	Cross-industry	30.86	5	−72.80	459.10	329.22	4	−3588.33	3678.06
4.	Industry productivity	Cross-country	35.01	4	−69.17	604.08	631.42	2	−9086.35	6377.78
5.	Firm-level productivity	N/A	18.49	7	−99.95	88.44	97.39	11	−256.77	157.72
6.	Preferences	Cross-industry	88.12	1	−70.88	723.56	172.27	8	−923.85	2021.77
7.	Preferences	Cross-country	20.15	6	−45.77	243.35	158.05	9	−2450.00	990.27
8.	Trade costs	Cross-industry	14.30	9	−84.35	86.04	258.85	5	−3030.44	3915.09
9.	Trade costs	Cross-country	13.16	10	−73.83	72.17	134.90	10	−1348.91	1799.73
10.	Trade costs—access to intermediates[d]		46.14	3	−56.79	301.96	351.84	3	−3303.19	3623.67
11.	Trade costs—localizing comparative advantage[e]		15.06	8	−75.41	75.55	176.60	6	−1507.33	2798.84
12.	Trade costs—linking preferences to specialization[f]		79.67	2	−89.43	658.28	991.57	1	−4255.83	27560.49

[a]Each simulation removes a particular determinant of trade.
[b]Specifies whether the cross-industry or cross-country variation has been removed.
[c]The average of absolute percent changes.
[d]This simulation removes cross-industry differences in trade costs and eliminates the cross-industry variation in dependence on intermediates.
[e]This simulation removes cross-industry and cross-country differences in trade costs.
[f]This simulation removes cross-industry differences in trade costs and sets the taste parameter to its cross-industry average value.

values of the percent changes.[39] These averages 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.

A. Results

Tables 5–8 summarize the results of the simulations. Each simulation entails the removal of the determinant of trade listed in the second column of each table. The third column of each table shows if a relevant parameter has been set to its cross-industry or cross-country in-sample average during the simulation.

Tables 5 and 6 show the effects of Simulations #1–12 on four variables: industry share, net exports, exports, and imports. As discussed in the previous section, changes in industry shares measure changes in specialization while changes in net exports measure changes in the pattern of trade. Exports and imports are shown in addition to net exports in order to better understand the changes in trade that take place during simulations.

The first four columns of numbers in Table 5 show the effects on the industry shares. The first column shows the average (across countries and industries) of the absolute values of the percent changes in industry shares. 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 second column of numbers shows the rank (1 through 12) of each determinant of trade according to the average absolute percent change in industry shares that its removal causes. Based on the previous discussion, higher ranked determinants of trade are deemed more important than the lower ranked ones. The rankings based on the four criteria (industry shares, net exports, exports, and imports) are similar (correlations are in the range of 0.6–0.7). The third and fourth columns of numbers show the range of the percent changes in the four variables.

Table 7 summarizes the rankings presented in Table 5 and calculates the average rank for each determinant of trade. Table 8 shows the

39. 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.

TABLE 6
Percent Changes of (Gross) Exports and Imports

			Exports				Imports			
Sim. #	Simulation[a]	Variation removed[b]	Av. of abs.[c]	Rank	Minimum	Maximum	Av. of abs.[c]	Rank	Minimum	Maximum
1.	Factor shares	Cross-industry	9.36	12	−42.13	69.02	6.21	12	−38.97	45.48
2.	Factor endowments	Cross-country	32.75	10	−18.36	336.18	12.18	11	−70.41	41.92
3.	Industry productivity	Cross-industry	173.80	3	−89.98	6364.68	55.50	9	−98.27	521.26
4.	Industry productivity	Cross-country	755.20	1	−84.25	38545.36	57.39	8	−98.80	413.40
5.	Firm-level productivity	N/A	99.41	4	−100.00	−83.16	95.37	4	−100.00	27.77
6.	Preferences	Cross-industry	82.13	6	−70.15	307.18	108.42	3	−71.21	1113.60
7.	Preferences	Cross-country	20.30	11	−37.27	92.42	33.76	10	−51.57	552.48
8.	Trade costs	Cross-industry	53.20	9	−90.18	293.68	67.04	7	−93.43	1112.93
9.	Trade costs	Cross-country	76.23	7	−98.09	1.77	71.94	6	−99.39	636.17
10.	Trade costs—access to intermediates[d]		98.71	5	−91.31	581.65	117.91	2	−85.83	1378.41
11.	Trade costs—localizing comparative advantage[e]		75.01	8	−97.23	46.74	80.62	5	−98.45	1024.40
12.	Trade costs—linking preferences to specialization[f]		226.94	2	−94.27	2892.03	358.65	1	−86.87	9344.95

[a]Each simulation removes a particular determinant of trade.
[b]Specifies whether the cross-industry or cross-country variation has been removed.
[c]The average of absolute percent changes.
[d]This simulation removes cross-industry differences in trade costs and eliminates the cross-industry variation in dependence on intermediates.
[e]This simulation removes cross-industry and cross-country differences in trade costs.
[f]This simulation removes cross-industry differences in trade costs and sets the taste parameter to its cross-industry average value.

TABLE 7
Summary of Ranks

Sim. #	Simulation[a]	Variation Removed[b]	Ind. Shares	Net Exp.	Av. Rank	Av. Rank 1–9[c]
1.	Factor shares	Cross-industry	12	12	12	9
2.	Factor endowments	Cross-country	11	7	9	6
3.	Industry productivity	Cross-industry	5	4	4.5	2.5
4.	Industry productivity	Cross-country	4	2	3	1.5
5.	Firm-level productivity	N/A	7	11	9	6.5
6.	Preferences	Cross-industry	1	8	4.5	3
7.	Preferences	Cross-country	6	9	7.5	5
8.	Trade costs	Cross-industry	9	5	7	4.5
9.	Trade costs	Cross-country	10	10	10	7
10.	Trade costs—access to intermediates[d]		3	3	3	
11.	Trade costs—localizing comparative advantage[e]		8	6	7	
12.	Trade costs—linking preferences to specialization[f]		2	1	1.5	

[a]Each simulation removes a particular determinant of trade.
[b]Specifies whether the cross-industry or cross-country variation has been removed.
[c]Average of ranks based only on Simulations #1–9.
[d]This simulation removes cross-industry differences in trade costs and the cross-industry variation in dependence on intermediates.
[e]This simulation removes cross-industry and cross-country differences in trade costs.
[f]This simulation removes cross-industry differences in trade costs and sets the taste parameter to its cross-industry average value.

effects on welfare, measured by real GDP, of each determinant of trade.

We first focus on Simulations #1–9 that study the direct effects of various determinants of trade. By contrast, Simulations #10–12 investigate the indirect effects of trade costs, whereby trade costs interact with other determinants of trade to influence the pattern of trade and specialization. Simulations #10–12 involve removing several determinants of trade at once.

The last column of Table 7 shows the average rank for each determinant of trade based only on

TABLE 8
Percent Changes of Welfare

Sim. #	Simulation[a]	Variation Removed[b]	Av. of Abs.[c]	Rank	Minimum	Maximum
1.	Factor shares	Cross-industry	0.41	12	−1.59	0.91
2.	Factor endowments	Cross-country	14.71	2	−8.89	56.58
3.	Industry productivity	Cross-industry	13.07	3	−1.73	31.34
4.	Industry productivity	Cross-country	105.41	1	−36.86	390.70
5.	Firm-level productivity	N/A	6.61	8	−17.27	13.92
6.	Preferences	Cross-industry	10.25	5	−23.11	21.47
7.	Preferences	Cross-country	10.69	4	−32.74	14.68
8.	Trade costs	Cross-industry	1.87	11	−4.83	9.70
9.	Trade costs	Cross-country	9.85	6	−22.49	3.46
10.	Trade costs—access to intermediates[d]		4.19	10	−15.27	7.39
11.	Trade costs—localizing comparative advantage[e]		8.98	7	−22.02	3.23
12.	Trade costs—linking preferences to specialization[f]		5.83	9	−8.73	26.60

[a]Each simulation removes a particular determinant of trade.
[b]Specifies whether the cross-industry or cross-country variation has been removed.
[c]The average of absolute percent changes.
[d]This simulation removes cross-industry differences in trade costs and the cross-industry variation in dependence on intermediates.
[e]This simulation removes cross-industry and cross-country differences in trade costs.
[f]This simulation removes cross-industry differences in trade costs and sets the taste parameter to its cross-industry average value.

Simulations #1–9. According to this ranking, the cross-country differences in productivity, which determine absolute advantages, have the greatest influence on the pattern of trade and specialization. Removing these differences (as in Simulation #4) changes industry shares by an average of 35%, net exports by 631%, exports by 755%, and imports by 57%. As we can see, the effects are especially large on exports and net exports.

The second greatest impact on the pattern of trade and specialization (according to the last column of Table 7) is caused by the cross-industry differences in productivity, which determine Ricardian comparative advantages. Their removal (as in Simulation #3) results in the industry shares changing by an average of 31% and net exports by 329%. Therefore, of all the determinants of trade studied in this paper, productivity differences (cross-country and cross-industry) have the largest effects on the pattern of trade and specialization.

Differences in tastes also have significant effects on trade and specialization. The fact that consumers spend different fractions of their income on different industries is the third most important determinant of trade. Removing these differences (Simulation #6) has a very large effect on specialization and imports, which is expected, and a smaller effect on exports and net exports. The fact that consumers in different countries have different tastes is the fifth most important determinant of trade. The removal of these differences (Simulation #7) has moderate effects on trade and specialization. One of the conclusions obtained from Simulations #6 and #7 is that, compared to other determinants of trade, preferences have a relatively greater effect on industry shares than on trade. This happens because trade costs link preferences with specialization. This link will be further investigated in the next section.

Simulations #8 and #9 study the effects of cross-industry and cross-country differences in trade costs on the pattern of trade and specialization. These effects are found to be moderate in magnitude. The influence of cross-industry differences in trade costs is ranked fourth while the effect of cross-country differences is ranked eighth (according to the last column of Table 7).

The results of Simulation #8 show that some industries are more sensitive than others to the removal of cross-industry differences in trade costs.[40] The Food industry is the most sensitive by far. For example, while the average industry share and net exports change by 14.3% and 258%, respectively (Table 5), the average Food industry share and net exports change by 20% and 760%. Wood industry is also sensitive to the

40. "Sensitivity" here is measured by the absolute percent changes in industry shares and net exports.

removal of cross-industry differences in trade costs, but much less so than the Food industry. The high sensitivity of the Food industry is explained by the high trade costs in that industry and by the fact that the trade costs in the Food industry are different from the trade costs in other industries (i.e., the correlation between the [country pair] trade costs in the Food industry and any other industry is noticeably lower than the correlation between the trade costs of any two non-Food industries).[41]

The effects of the firm-level productivity differences on specialization and trade are moderate. The main effect of removing these productivity differences is to reduce the volume of trade. The exports and imports are moderately affected, but the net exports and specialization do not change as much (because exports and imports are reduced by similar proportions).

Finally, the effects of factor endowments on trade and specialization are found to be small. Simulation #1 measures 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%. According to the last column of Table 7, the effects of factor endowments are ranked seventh. Table 6 shows that the effects of factor endowments on exports and imports are also small relative to the other determinants of trade.

Simulation #2 measures the effect of factor endowments by removing factor intensity differences across industries. Removing these differences causes the average industry share to change by a small 3.9% and net exports by 58%. The effects of factor intensity differences are ranked last in Table 7. Therefore, factor endowments are found to be much less influential than productivity in determining the pattern of trade and specialization. However, the second subsection of IV.A has something interesting to add to the factor endowment story.

We now turn to the indirect effects of trade costs, whereby trade costs interact with other determinants of trade to influence the pattern of trade and specialization. These indirect effects are studied in Simulations #10–12.

The results show that trade costs, especially by linking preferences to specialization (Simulation #12) and affecting access to intermediates (Simulation #10), have great effects on trade and specialization. For example, de-linking preferences and specialization, as in Simulation #12, changes industry shares by an average of almost 80%, net exports by almost 1000%, exports by 226%, and imports by 358%. The third column of numbers in Table 7 shows that the effects of Simulation #12 are the greatest among the effects of all 12 simulations performed in this paper. The effects of Simulation #10 (which removes the trade costs' impact on the access to intermediates) have the second highest rank among the 12 simulations, same as the effects of Simulation #4 (which removes the cross-country differences in productivity).

Trade costs also affect the pattern of trade and specialization by localizing comparative advantage. This effect of trade costs, studied in Simulation #11 is of moderate size—the average rank of this effect is 7. The next section will further investigate the interaction between trade costs and several other determinants of trade.

Table 8 shows the effects of the determinants of trade on welfare. Not surprisingly, cross-country industry level productivity differences (i.e., absolute advantages) have by far the greatest effects on welfare. The rest of trade determinants are much less important. For example, cross-country factor endowment differences have (on average) the second largest effects on welfare, but they are much smaller than the effects of absolute technological advantages.

More on Trade Costs. As mentioned earlier, theory predicts that trade costs affect the pattern of trade and specialization by, among other things, interacting with the determinants of comparative advantage and preferences. Specifically, trade costs reduce the geographic range of comparative advantages and link preferences with production. To further investigate these effects of trade costs, Simulations #1–3 and #7 are repeated with trade costs set to one (i.e., with free trade). The results are presented in Table 9. 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 ($d_{nij} = 1$ for all n, i, and j).

The results of Simulations #1–3 show that, as expected, the factor endowment- and productivity-based comparative advantages become more influential when trade costs are removed. With the current level of trade costs,

41. Specifically, consider the $J \times J$ correlation matrix where each element is $\rho_{jm} = corr\left(d_{nij}, d_{nim}\right)$ and n and i go from 1 to N. In this case, $\rho_{\text{Food},m} < \rho_{jm}$ for all j and m.

TABLE 9

Interaction Between Trade Costs and Some of the Determinants of Comparative Advantage

			Effects on Ind. Shares[c]		Effects on Net Exp.[c]	
Sim. #	**Simulation[a]**	**Variation Removed[b]**	**With Current Trade Costs**	**With Free Trade**	**With Current Trade Costs**	**With Free Trade**
1.	Factor shares	Cross-industry	3.88	7.42	58.04	91.68
2.	Factor endowments	Cross-country	4.76	6.11	175.29	109.51
3.	Industry productivity	Cross-industry	30.86	102.27	329.22	808.45
7.	Preferences	Cross-country	20.15	9.98	158.05	1091.34

[a]Each simulation removes a particular determinant of trade.
[b]Specifies whether the cross-industry or cross-country variation has been removed.
[c]The numbers are the averages of absolute percent changes.

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 0 if all trade is inter-industry and 1 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.[42] With the current levels of trade costs, removing industry-level productivity differences (as in Simulation #3) increases the GL index 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.

Repeating Simulation #3 with all trade costs set to 1, 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.

42. For comparison, it is 0.45 in the trade data.

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 free 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.

Finally, 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 #7 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%).[43]

Richer Versus 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 divide the countries in the data set into two groups. One group includes all the countries that had 1989 GDP per capita less than half of the U.S. level. This group includes Greece, Korea, Mexico, Portugal, Spain, Turkey, and is called the middle-income group. The second group,

43. 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.

TABLE 10

Poorer Versus Richer Countries: Effects on Industry Shares and Net Exports

			Effects on Industry Shares[a]				Effects on Net Exports[a]			
Sim. #	Simulation[b]	Variation Removed[c]	All	Poorer[d]	Richer[d]	Poorer/ Richer	All	Poorer[d]	Richer[d]	Poorer/ Richer
1.	Factor shares	Cross-industry	3.88	9.23	1.41	6.53	58.04	123.88	27.65	4.48
2.	Factor endowments	Cross-country	4.76	9.28	2.67	3.47	175.29	435.48	55.21	7.89
3.	Industry productivity	Cross-industry	30.86	45.41	24.14	1.88	329.22	445.76	275.44	1.62
4.	Industry productivity	Cross-country	35.01	54.07	26.21	2.06	631.42	1091.80	418.93	2.61
5.	Firm-level productivity	N/A	18.49	22.94	16.44	1.40	97.39	93.61	99.13	0.94
6.	Preferences	Cross-industry	88.12	102.40	81.53	1.26	172.27	220.08	150.21	1.47
7.	Preferences	Cross-country	20.15	29.41	15.88	1.85	158.05	240.08	120.18	2.00
8.	Trade costs	Cross-industry	14.30	17.40	12.88	1.35	258.85	324.45	228.58	1.42
9.	Trade costs	Cross-country	13.16	17.84	11.00	1.62	134.90	128.32	137.94	0.93
10.	Trade costs—access to intermediates[e]		46.14	47.98	45.29	1.06	351.84	452.28	305.49	1.48
11.	Trade costs—localizing comparative advantage[f]		15.06	19.50	13.01	1.50	176.60	152.37	187.79	0.81
12.	Trade costs—linking preferences to specialization[g]		79.67	85.46	76.99	1.11	991.57	1276.38	860.11	1.48

[a]The numbers are the averages of absolute percent changes.
[b]Each simulation removes a particular determinant of trade.
[c]Specifies whether the cross-industry or cross-country variation has been removed.
[d]Poorer countries are those with 1989 GDP/capita less than half of the United States, richer are all others.
[e]This simulation removes cross-industry differences in trade costs and the cross-industry variation in dependence on intermediates.
[f]This simulation removes cross-industry and cross-country differences in trade costs.
[g]This simulation removes cross-industry differences in trade costs and sets the taste parameter to its cross-industry average value.

that includes all the other countries, is the high-income group.

Table 10 shows the average absolute percent changes in the industry shares and net exports of all countries (repeated from the corresponding columns of Table 5), middle-income countries, and high-income countries. The last column shows the ratio of the middle-income countries' to high-income countries' averages. A higher ratio means a greater difference in the effect of a particular determinant of trade on poorer versus richer countries.[44]

The results clearly show that the greatest relative difference between the middle-income and high-income countries is in the effects of factor endowments and factor intensities. The effects of these determinants in the middle-income countries are 3.5 to 7.9 times greater than in the high-income countries.[45] This supports the notion that the Heckscher–Ohlin reason for trade is more applicable to poorer than to richer countries. 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.[46] These conclusions about the Heckscher–Ohlin reason for trade are especially interesting because they obtain not only when factor endowments differences are neutralized (Simulation #2), but also when factor intensity differences (which are the same in the richer and poorer countries) are eliminated (Simulation #1). It seems that poorer countries rely more on their factor endowment advantages (e.g., lower wages) in their specialization and trade than do richer countries.

44. Note that all the numbers in each row of Table 10 come from the same simulation, that is the numbers for the richer and poorer countries come from the same experiment.

45. There is a strong negative correlation between the income level and the effect on industry shares and net exports in Simulations #1 and #2 (−0.9 and −0.81, respectively). This correlation is much weaker in Simulations #3 and 4 (−0.62 and −0.68, respectively). 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.

46. 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%.

TABLE 11
Poorer Versus Richer Countries: Effects on Exports and Imports

			Effects on (Gross) Exports[a]				Effects on (Gross) Imports[a]			
Sim. #	Simulation[b]	Variation Removed[c]	All	Poorer[d]	Richer[d]	Poorer/ Richer	All	Poorer[d]	Richer[d]	Poorer/ Richer
1.	Factor shares	Cross-industry	9.36	21.96	3.55	6.19	6.21	13.34	2.92	4.57
2.	Factor endowments	Cross-country	32.75	83.94	9.13	9.20	12.18	24.46	6.51	3.76
3.	Industry productivity	Cross-industry	173.80	333.04	100.31	3.32	55.50	57.72	54.47	1.06
4.	Industry productivity	Cross-country	755.20	2025.30	169.00	11.98	57.39	54.16	58.88	0.92
5.	Firm-level productivity	N/A	99.41	99.65	99.30	1.00	95.37	92.82	96.55	0.96
6.	Preferences	Cross-industry	82.13	69.67	87.89	0.79	108.42	152.50	88.08	1.73
7.	Preferences	Cross-country	20.30	24.88	18.18	1.37	33.76	51.25	25.69	2.00
8.	Trade costs	Cross-industry	53.20	57.10	51.40	1.11	67.04	58.13	71.15	0.82
9.	Trade costs	Cross-country	76.23	74.59	76.99	0.97	71.94	59.59	77.63	0.77
10.	Trade costs—access to intermediates[e]		98.71	99.95	98.13	1.02	117.91	134.11	110.43	1.21
11.	Trade costs—localizing comparative advantage[f]		75.01	72.96	75.96	0.96	80.62	64.64	87.99	0.73
12.	Trade costs—linking preferences to specialization[g]		226.94	281.01	201.99	1.39	358.65	580.96	256.05	2.27

[a]The numbers are the averages of absolute percent changes.
[b]Each simulation removes a particular determinant of trade.
[c]Specifies whether the cross-industry or cross-country variation has been removed.
[d]Poorer countries are those with 1989 GDP/capita less than half of the United States, richer are all others.
[e]This simulation removes cross-industry differences in trade costs and the cross-industry variation in dependence on intermediates.
[f]This simulation removes cross-industry and cross-country differences in trade costs.
[g]This simulation removes cross-industry differences in trade costs and sets the taste parameter to its cross-industry average value.

Most, but not all, of the other determinants of trade are also more influential in the poorer than richer countries.[47] The impact of the cross-country productivity differences (which determine absolute advantages) is about 2.1–2.6 times greater in the poorer countries. The influence of the cross-industry productivity differences (which determine comparative advantages) is about 1.6–1.9 times greater in the poorer countries. It appears that richer countries base their specialization and trade more on their technological advantages than on their capital abundance advantages.

The effects of the cross-country taste differences are about 1.8–2 times greater in the poorer countries. The effects of trade costs do not seem to vary much with income level. In fact, some simulations (#9 and #11) show a greater influence of trade costs on net exports of the richer than poorer countries.

Table 11 shows the differential impacts of various determinants of trade on the exports and imports of the middle-income and high-income countries. The results shown in this table are generally similar to those shown in Table 10 with one exception. The effects of the cross-country differences in industry-level productivity on industry shares and net exports are moderately greater in the middle-income than high-income countries. However, their effects on exports are much greater in the poorer countries. At the same time, the effects on the imports are about the same in the two groups of countries. This is not surprising since eliminating cross-country productivity differences significantly increases the relative productivities of the poorer countries, thus boosting their exports in all industries.

Some of the results presented in this paper may depend on the particular industrial classification system used (this paper uses the SIC industrial classification, the most common one in the world). Specifically, the relative importance of factor endowments, technology,

47. All determinants of trade have a greater effect of specialization of poorer than richer countries (i.e., all values in the fourth column of numbers of Table 10 are greater than 1). Most (9 out of 12) determinants also have a greater effect on the net exports of poorer than richer countries (i.e., 9 out 12 values in the last column of numbers of Table 10 are greater than 1). As richer countries are more open (i.e., have lower trade costs) than poorer countries, some determinants of trade may end up having slightly more effect on the net exports of richer than poorer countries, even if the specialization is more affected in the poorer countries.

and tastes may be different for a different classification system. However, the important and many-sided role of trade costs is not affected by the classification system. Most of the effects of trade costs are conditional on their total magnitudes, not on their cross-industry differentials. The relatively greater importance of factor endowments in the poor countries is also independent of the industrial classification system used.

V. CONCLUSION

This 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 the pattern of trade. The effects of various determinants of trade on welfare are also presented.

The results show that the productivity differences and differences in tastes are the first and second most significant determinants of trade and specialization. Cross-country productivity differences are also found to have very large effects on welfare. By most measures, factor endowments are found to be the least influential determinant of trade for the average country in the data set.

The results also show the great importance of trade costs. While previous literature has demonstrated their significance for the volume of trade, this paper shows their importance for specialization and the pattern of trade. The direct effects of trade costs, that exist because trade costs are different across countries and industries, are found to be moderate. However, the indirect effects of trade costs, whereby trade costs interact with other determinants of trade, are found to be very significant. For example, trade costs link domestic production with domestic preferences and affect access to intermediate goods. Trade costs also decrease the geographic range of comparative advantage forces, in effect making them local rather than global. 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.

This 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 poorer countries than in richer ones, but the factor endowments especially so. Their effects in poorer countries are many times greater than in richer ones. In 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 poorer countries than richer ones.

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