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Trade Theory and Trade Facts*

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ABSTRACT

This paper quantitatively tests the "new trade theory" based on product differentiation, increasing returns, and imperfect competition. We employ a model that allows both changes in the shares of income among industrialized countries, emphasized by Helpman and Krugman (1985), and nonhomothetic preferences, emphasized by Markusen (1986), to affect trade volumes and directions. In addition, we generalize the model to allow changes in relative prices to have large effects. We test the model by calibrating it to 1990 data and then "backcasting" to 1961 to see what changes in crucial variables between 1961 and 1990 are predicted by the theory. The results show that, although the model is capable of explaining much of the increased concentration of trade among industrialized countries, it is not capable of explaining the enormous increase in the ratio of trade to income.

JEL classification numbers: F120, F130, F170. **Key words:** product differentiation, imperfect competition, scale economies, nonhomothetic preferences, trade growth, intraindustry trade.

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1. Introduction

This paper investigates the extent to which the "new trade theory" can quantitatively match some of the facts that it was designed to explain. We do this calibrating a standard model, based on Markusen (1986), to 1990 data and then "backcasting" to 1961 to see what changes in crucial variables between 1961 and 1990 are predicted by the theory.

The new trade theory, developed by researchers like Helpman (1981), Krugman (1979), and Lancaster (1980) in the late 1970s and 1980s, was motivated by the failure of more traditional theories to explain some of the most significant facts about post World War II trade data. As Deardorff (1984) and Helpman and Krugman (1985) explain, the new trade theory was designed to account for three major facts:

- The ratio of trade to GDP has increased.
- Trade has become more concentrated among industrialized countries.
- Trade among industrialized countries is largely intraindustry trade.

Figure 1 presents evidence for the first fact, showing how much faster world trade has increased than world GDP. To make comparisons easy in the figure, data on both world trade volume, measured by summing up exports throughout the world, and world GDP have been expressed as indices where 1950 = 100. Over the period 1950–1990, the ratio of trade to GDP worldwide increased by 86.1 percent. The data for both trade and GDP used to derive the indices in Figure 1 are measured in constant 1970 U.S. dollars. Alternatively, we could look at trade as a fraction of GDP, dividing the current value of trade by the current value of GDP. As a fraction of the value of GDP, the value of trade increased from 7.9 percent in 1950 to 15.4 percent in 1990, a 94.9 percent increase.

To make the second fact precise, we identify industrialized countries with the Organisation for Economic Co-operation and Development (OECD), which was formed in 1961. Trade within the OECD has increased much faster than OECD trade with the rest of the world. The ratio of OECD-OECD trade to OECD-RW trade went from 0.84 in 1961 to 1.58 in 1990.

Evidence for the third fact can be found in the high Grubel-Lloyd indices of international trade in industrialized countries. For this sort of data it is more difficult to calculate long time series. In 1990 though, Grubel-Lloyd indices based on two-digit SITC data from the OECD say that 68.4 percent of OECD-OECD trade was intraindustry compared with only 38.1 percent of OECD-RW trade.

Closely related to the first two facts is yet a fourth fact: The ratio of trade to GDP within the OECD increased even faster than the ratio of trade to GDP worldwide. Trade within the OECD went from 5.3 percent of OECD GDP in 1961 to 11.2 percent in 1990, an increase of 111.5 percent. By comparison the United Nations data say that the ratio of trade to GDP worldwide increased by only 59.3 percent over 1961–1990.

That the new trade theory was developed to explain these sorts of facts is explicit in textbook expositions by the developers of the theory. Helpman and Krugman (1985), for example, point out that conventional trade models like the Ricardian model and the Heckscher-Ohlin model cannot hope to explain these facts and go on to say,

> These . . . empirical weaknesses of conventional trade theory . . . become understandable once economies of scale and imperfect competition are introduced into our analysis.

Helpman and Krugman stress the changes in the distribution of income among industrialized countries as their theory's principal mechanism for accounting for the observed expansion of trade relative to income. In the early post war period the United States accounted for much of the world's income and consumption. As the distribution of national income became more equal, their model predicts that trade volumes should rise.

Focusing on the large amount of trade among industrialized countries relative to the trade with less developed economies, Markusen (1986) stresses unequal income elasticity of demands that results from nonhomothetic preferences. If demand for differentiated products is superior to that for homogeneous products, then intraindustry trade should be larger the larger income is; and, if industrialized countries are net exporters of these differentiated products, then intraindustry trade among industrialized countries should increase relative to trade with less developed countries. Thus, as the world gets richer, trade among industrialized countries should expand faster than other trade. As Markusen *et al.* (1995) point out, it was to match the facts listed above that the theory had been formulated:

> Thus, nonhomogeneous demand leads to a decrease in North-South trade and to an increase in [intraindustry trade] among the northern industrialized countries. These are precisely the facts there were to be explained.

Our model generalizes those developed by Helpman and Krugman (1985) and Markusen (1986) in that it allows changes in relative prices to have large effects on trade volumes. Because of faster total factor productivity growth in the manufacturing sector, the relative prices of manufactured goods have fallen sharply from 1961 to 1990 compared to the prices of primary goods and services.

The new trade theory has made a fundamental contribution in providing a tractable framework for analyzing the large volume of intraindustry trade. In this paper, we focus on a very specific question: To what extent can the new trade theory account for the observed dynamic behavior of trade volumes and directions? Deardorff (1984), for example, stresses that the growth of intraindustry trade is an empirical phenomenon not well explained by older, traditional theories. Our numerical experiments show that, although the model can explain a large part of the increased concentration of trade among industrialized countries, it is not capable of explaining the enormous increase in the ratio of trade to income. It has been the trade of manufactured goods among OECD countries that accounts for most of the expansion of trade over the period 1961–1990. Over this same period, however, the production of manufactures in these countries has declined sharply as a fraction of total production. A model that relies on the taste for variety approach developed by Spence (1976) and Dixit and Stiglitz (1977) links increases in trade to increases in production.

The model that we employ is a static general equilibrium model with three sectors — primaries, manufactures, and services. While primaries and services are produced under constant returns and perfect competition, manufactures are differentiated goods produced under increasing returns and monopolistic competition as in Dixit and Stiglitz (1977). Primaries and manufactures are tradable goods, while services are nontradable. It is worth noting that lack of data on trade in services in 1961 forces us to restrict our attention to merchandise trade in both our data analysis and in our theory. (Information on sources for all of the data presented in this paper is included in the data appendix.)

To preview our results and to understand the difficulty that the new trade theory has in accounting for the enormous increase in the ratio of trade to GDP observed among OECD countries over the period 1961–1990, we can put some numbers to the simple calculations done in Helpman and Krugman (1985). Consider a model of n countries that differ only in size. Suppose that only manufactures are traded. Since the Dixit-Stiglitz (1977) specification of taste for variety implies that consumers in each country consume the same basket of differentiated goods from across all of the countries, country j exports all of its production of manufactures Y_m^j except for the fraction that it retains for domestic consumption. This fraction is equal to the share of country j in world income, $s^j = Y^j / Y^w$. This implies that the total trade in manufactures among these countries is

$$M = \sum_{j=1}^{n} \left(1 - s^j\right) Y_m^j . \tag{1}$$

Since the countries are all identical except for size, we also know that $Y_m^j = s^j Y_m^w$. Some simple algebra implies that

$$\frac{M}{Y_m^w} \frac{Y_m^w}{Y^w} = \frac{M}{Y^w} = \left(1 - \sum_{j=1}^{n} (s^j)^2\right) \frac{Y_m^w}{Y^w}. \tag{2}$$

In the data, the index of size distribution of national incomes in the OECD, $\left(1 - \sum_{j=1}^{n} (s^j)^2\right)$, goes from 0.6634 in 1961 to 0.8272 in 1990, producing the increase in trade to income emphasized by Helpman and Krugman (1985). To produce the most favorable possible results for the new trade theory, we allow the membership of the OECD to increase over time, with n rising from 19 in 1961 to 23 in 1990 — if we keep the OECD fixed at its 1961 membership, then $\left(1 - \sum_{j=1}^{n} (s^j)^2\right)$ goes from 0.6634 to only 0.7764. The ratio of manufacturing GDP to total GDP in the OECD, Y_m^{oe} / Y^{oe}, falls, however, from 0.2948 in 1961 to 0.2222 in 1990. Notice that these two changes almost exactly cancel each other out, producing the prediction of no increase in the ratio of OECD-OECD trade to OECD GDP. (Actually, the calculation predicts a small decline in the ratio.)

$$0.6634 \times 0.2948 = 0.1956 \approx 0.1838 = 0.8272 \times 0.2222 . \tag{3}$$

The calibrated general equilibrium model used in this paper accounts for many more elements in the data, such as trade in primaries and trade between the OECD and the rest of the world. Nevertheless, the central message of our numerical experiments with different versions of the model comes close to the message of these back-of-the-envelope calculations. That is, any version of our model that accounts of the decline in the share of manufactures in output — and here price effects play an import role in the model — cannot account for the increase in the ratio of trade to GDP. The simple fact is that the goods that are being traded more and more among OECD countries are precisely the goods that are becoming less important as a share of output or of consumption. To keep the specification of our model and its calibration simple, we start with a version in which there are no intermediate goods. Since authors like Feenstra (1998) stress the importance of intermediate goods trade, we also include a version of the model with intermediate goods. Results of numerical experiments with this model are similar to those of the model without intermediate goods; if anything, including intermediate goods produces results less favorable to the Helpman-Krugman (1985) explanation of the growth of world trade.

Introducing the sort of nonhomothetic preferences stressed by Markusen (1986) into our model, we are more successful in accounting for the increased concentration in trade among OECD countries over time. As countries become richer, the declining consumption share of primaries means that the countries in the rest of the world, which are net exporters of these goods, suffer declining shares in world trade. This phenomenon is, of course, related to the elasticity pessimism behind the import substitution theory reviewed by Bruton (1998).

That our model is not successful in accounting for the increase in the ratio of trade to GDP in the data does not mean that the mechanism stressed by Helpman and Krugman (1985) that relies on the index of size distribution of national incomes $\left(1-\sum_{j=1}^{n}(s^{j})^{2}\right)$ does not play a significant role. Our numerical experiments indicate that the ratio of trade to GDP would have fallen sharply without the increase in this index. Rather, our results indicate that we must find another mechanism for generating the huge increase observed in trade. We present some simple calculations suggesting that this mechanism may be changes in trade policy. As noted by Krugman (1995), that changes in policy may have been more important than the mechanisms stressed by the new trade theory in explaining the huge increase in trade volumes can help explain why the ratio of trade to GDP was as high in the late nineteenth century as it is today. Of course, reductions in trade barriers provide a mechanism that can generate increases in trade in traditional models as well as in new trade theory models. Kehoe (2003) examines the performance of applied general equilibrium models of the impact of the North American Free

Trade Agreement whose specifications were based on the new trade theory. He argues that it was this sort of specification that led these models to grossly under predict the impact of this set of policy changes on trade flows in North America. Yi (2003) argues that we need a model in which increases in trade come from previously nontraded goods becoming traded — like a Ricardian model — to explain the impact of changes in trade policy on trade volumes. He also stresses that it is changes in trade policy that give intermediate goods trade a crucial role to play in generating increases in trade.

Although no other paper has tested the new trade theory using a calibrated general equilibrium model like that in this paper, there is a vast related empirical literature. Here we mention only a few of the most closely related papers: Hunter (1991) estimates that nonhomothetic preferences accounts for about one-fourth of observed interindustry trade. Helpman (1987) reports a positive correlation between a dispersion of size index and trade to GDP for 14 industrialized countries during the 1956–1981 period. He interprets this result as support for the Helpman-Krugman explanation of the distribution of national income as the driving force behind trade increases. Hummels and Levinsohn (1995), however, argue that Helpman's results are not conclusive tests of the Helpman-Krugman theory. Haveman and Hummels (1999) further argue that the new trade theory models rely on taste for variety that is not consistent with the data and predict too much trade. Baier and Bergstrand (2001) estimate a gravity equation based upon a monopolistically competitive general equilibrium model to study the sources of trade increases for several OECD countries between the late 1950s and the late 1980s. With their estimates, trade liberalization appears to have contributed 75 percent of the growth of world trade as a share of GDP; the rest being explained by transport cost declines. Income convergence, as considered by the new trade theory, explains virtually none of the increase in the ratio of trade to GDP.

2. A "New Trade Theory" Model

Consider a world in which there are n developed countries, identified with the 23 countries in the Organisation for Economic Co-operation and Development (OECD) in 1990, and a rest of the world. (There were actually 24 countries in the OECD in 1990, but, since trade data for Belgium and Luxembourg are aggregated together, we treat them as one country.)

In each country or region, there are three types of goods, a primary good that is tradable and homogeneous, manufactured goods that are tradable and differentiated by the firm that produces them, and a service good that is nontradable and homogeneous within the country where it is produced. The OECD and the rest of the world differ in the endowments of physical capital and human capital held by consumers. Specifically, the endowments of OECD consumers are k^{oe} and h^{oe} while those of consumers in the rest of the world are k^{rw} and h^{rw}.

An individual consumer in country or region j, $j=1,\ldots,\ n,oe,rw$, solves the problem of maximizing

$$\left[\beta_p(c_p^j+\gamma_p)^\eta+\beta_m\left(\int_{D^w}c_m^j(z)^\rho dz\right)^{\eta/\rho}+\beta_s(c_s^j+\gamma_s)^\eta-1\right]\Big/\eta \tag{4}$$

subject to

$$q_pc_p^j+\int_{D^w}q_m(z)c_m^j(z)dz+q_s^jc_s^j\le r^jk^j+w^jh^j,\quad c_p^j,c_m^j(z),c_s^j\ge 0. \tag{5}$$

Here c_p^j is the consumption of the primary good and q_p is its price; $c_m^j(z)$ is the consumption of the manufactured good produced by firm z and $q_m(z)$ is its price; c_s^j is the consumption of the service good and q_s^j is its price; and r^j is the return to physical capital while w^j is the return to human capital. Notice that, since we assume that consumers in different OECD countries have the same endowments k^{oe} and h^{oe}, $c_i^1=c_i^2=\ldots=c_i^n=c_i^{oe}$, $i=p,m,s$. The parameter ρ, $1\ge\rho>0$, governs the elasticity of substitution $1/(1-\rho)$ between any two differentiated manufactured goods in the interval $D^w=[0,d^w]$ of such goods produced throughout the world; the parameters γ_p and γ_s govern the income elasticities of demand for the different types of goods; and the parameter η governs the elasticity of substitution between any two types of goods, which in turn governs the price elasticities of demand for the different types of goods. In the base case, where $\gamma_p=\gamma_s=\eta=0$, all of the income elasticities and price elasticities are equal to one. In this case, the utility function is

$$\beta_p\log c_p^j+\beta_m\left(\int_{D^w}c_m^j(z)^\rho dz\right)^{1/\rho}+\beta_s\log c_s^j. \tag{6}$$

The population of each country or region j, $j=1,\ldots,\ n,oe,rw$, is N^j. Of course, we require

$$N^{oe} = \sum_{j=1}^{n} N^j \,. \tag{7}$$

The aggregate endowments of human and physical capital are respectively

$$H^j = N^j h^j \tag{8}$$

$$K^j = N^j k^j \,. \tag{9}$$

In the homothetic utility case, where $\gamma_p = \gamma_s = 0$, there is no need to keep separate track of N^j, but in the nonhomothetic case there is.

Both the primary and the service good in country j are produced according to constant returns production functions,

$$Y_p^j = \theta_p (K_p^j)^{\alpha_p} (H_p^j)^{1-\alpha_p} \tag{10}$$

$$Y_s^j = \theta_s (K_s^j)^{\alpha_s} (H_s^j)^{1-\alpha_s} \,. \tag{11}$$

In contrast, the technology for producing manufactured goods exhibits increasing returns to scale because of the presence of fixed costs. Specifically, every firm z has the production function

$$Y_m(z) = \max\left[\theta_m K_m(z)^{\alpha_m} H_m(z)^{1-\alpha_m} - F, 0\right]. \tag{12}$$

Here $F > 0$ is the level of fixed costs.

The firms in the manufacturing sector are monopolistic competitors. Firm z in country or region j sets its price $q_m(z)$ to maximize profits

$$\Pi(z) = q_m(z) Y_m(z) - r^j K_m(z) - w^j H_m(z) \tag{13}$$

taking all of the other prices q_p, $q_m(z')$, q_s, r^j, w^j as given. To do so, the firm solves the maximization problems of all the consumers to obtain the world demand function for its good

$$Y_m(z) = \sum_{j=1}^{n} C_m^j(z) + C_m^{rw}(z) \,. \tag{14}$$

Here

$$C_m^j(z) = \frac{\beta_m^{\frac{1}{1-\eta}} (r^j K^j + w^j H^j + q_p \gamma_p N^j + q_s^j \gamma_s N^j)}{q_m(z)^{\frac{1}{1-\rho}} \left[\int_{D^w} q_m(z')^{\frac{-\rho}{1-\rho}} dz'\right]^{\frac{\rho-\eta}{\rho(1-\eta)}} \Delta} \tag{15}$$

where

$$\Delta = \beta_p^{\frac{1}{1-\eta}} q_p^{-\frac{\eta}{1-\eta}} + \beta_m^{\frac{1}{1-\eta}} \left[\left(\int_{D^w} q_m(z')^{\frac{-\rho}{1-\rho}} dz'\right)^{\frac{-(1-\rho)}{\rho}}\right]^{\frac{-\eta}{1-\eta}} + \beta_s^{\frac{1}{1-\eta}} q_s^{-\frac{\eta}{1-\eta}} \,. \tag{16}$$

Given its choice of output, the firm chooses $K_m(z)$ and $H_m(z)$ to minimize costs.

Let $c(r^j, w^j, Y_m(z))$ be the solution to the cost minimization problem of firm z :

$$c(r^j, w^j, Y_m^w(z)) = \frac{1}{\theta_m}\left(\frac{r^j}{\alpha_m}\right)^{\alpha_m}\left(\frac{w^j}{1-\alpha_m}\right)^{1-\alpha_m}(Y_m(z)+F). \tag{17}$$

Then we can write the profits (13) of firm z as

$$\Pi(z) - Aq_m(z)^{-\frac{\rho}{1-\rho}} - B^j Aq(z)^{-\frac{1}{1-\rho}} - B^j F. \tag{18}$$

Here we have expressed

$$Y_m(z) = Aq_m(z)^{-\frac{1}{1-\rho}} \tag{19}$$

$$c(r^j, w^j, Y_m(z)) = B^j(Y_m(z)+F). \tag{20}$$

where A and B^j are the appropriate expressions derived from equations (14)-(17). Differentiating profits (18) with respect to $q_m(z)$ and setting the derivatives equal to zero yields the familiar Lerner condition for profit maximization

$$q_m(z) = B^j/\rho. \tag{21}$$

Here the price elasticity of demand for good z is $1/(1-\rho)$. It is straightforward to show that this is the same result that we find if we assume that firms set quantities rather than prices.

We determine the number of firms d^w by allowing free entry and requiring that the profits of all firms are equal to zero. Using the Lerner condition (21), we can rewrite profits (13) as

$$\Pi(z) = B^j Y_m^w(z)/\rho - B^j Y_m^w(z) - B^j F. \tag{22}$$

Setting this expression equal to zero, we obtain

$$Y_m^w(z) = \frac{\rho}{1-\rho}F. \tag{23}$$

Definition. *An* ***equilibrium*** *is a vector of prices* q_p, $q_m(z)$, q_s, r^j, w^j, *and quantities,* c_p^j, $c_m^j(z)$, c_s^j, C_p^j, $C_m(z)$, C_s^j, Y_p^j, K_p^j, H_p^j, $Y_m(z)$, $K_m(z)$, $H_m(z)$, Y_s^j, K_s^j, H_s^j, $z \in D^w$, j, $j = 1,\ldots, n, rw$, *an interval of firms* D^w, *and a measure of firms for each country or region,* D^j, $j = 1,\ldots, n, rw$, *such that*

1. *Given the prices, the individual consumption plans* c_p^j, $c_m^j(z)$, c_s^j *solve the utility maximization problem of consumer* j (4)-(5);

2. The factor prices r^j, w^j, and the production plans for the primary and service good satisfy the conditions for zero profit and cost minimization

$$r^j = q_p \alpha_p \theta_p \left(H_p^j / K_p^j\right)^{1-\alpha_p} = q_s \alpha_s \theta_s \left(H_s^j / K_s^j\right)^{1-\alpha_s} \tag{24}$$

$$w^j = q_p\left(1-\alpha_p\right)\theta_p\left(K_p^j / H_p^j\right)^{\alpha_p} = q_s\left(1-\alpha_s\right)\theta_s\left(K_s^j / H_s^j\right)^{\alpha_s}; \tag{25}$$

3. *Each manufacturing firm z in country or region j chooses price* $q_m(z)$ *to maximize profits* (21). *Given output* $Y_m(z)$, *it chooses inputs* $K_m(z)$, $H_m(z)$ *to minimize costs*;

4. *Every firm* $z \in D^w$ *earns zero profits* (23);

5. *The markets for goods clear,*

$$\sum_{j=1}^{n,rw} N^j c_p^j \left(= \sum_{j=1}^{n,rw} C_p^j\right) = \left(\sum_{j=1}^{n,rw} Y_p^j\right) \tag{26}$$

$$\sum_{j=1}^{n,rw} N^j c_m^j(z) \left(= \sum_{j=1}^{n,rw} C_m^j(z)\right) = Y_m(z), \quad z \in D^w \tag{27}$$

$$N^j c_s^j (= C_s^j) = Y_s^j, \quad j = 1, \ldots, n, rw; \tag{28}$$

6. *The factor markets clear,*

$$K_p^j + \int_{D^j} K_m(z)dz + K_s^j = K^j, \quad j = 1, \ldots, n, rw \tag{29}$$

$$H_p^j + \int_{D^j} H_m(z)dz + H_s^j = H^j, \quad j = 1, \ldots, n, rw; \tag{30}$$

7. *The number of variety available for consumption is the number of varieties produced,*

$$D^w = D^1 \cup D^2 \cup \cdots \cup D^n \cup D^{rw}. \tag{31}$$

If factor prices in the OECD and the rest of the world are equal, then all of the manufacturing firms are faced with symmetric problems. Consequently, they all set the same quantities and charge the same prices. Since there are 2 traded goods prices and 2 factors of production, we know that factor prices are, in fact, equal across regions if both regions produce both goods. This suggests a simple procedure for computing equilibrium common in trade models: We compute an integrated equilibrium model for the world economy. We then compute the production plan for each region. As long as both regions produce both goods, we are done with the computation. If one of the regions were to produce negative amounts of one of the goods, we would be wrong to assume that factor prices were equal. In this case we would have to go back and compute an equilibrium in which at least one of the countries specializes. (We are not very interested in these sorts of equilibria, however, because they do not correspond with observed world production patterns in 1961 and 1990.)

We solve the model for a world with two regions, the OECD and the rest of the world, each of which is made up of different countries. To see how the theory matches up with the data, however, it is essential that we be able to calculate intraindustry trade in manufactures within the OECD and between the OECD and the rest of the world.

To calculate intraindustry trade in our model in which trade in manufactures is unbalanced, we need to generalize the approach developed by Helpman and Krugman (1985). Let s^j be the share of country or region j, $j = 1, \ldots, n, rw$ in the world production of manufactures,

$$s^j = \int_{D^j} Y_m(z)dz \Big/ \int_{D^w} Y_m(z)dz = Y_m^j / Y_m^w . \qquad (32)$$

Let C_m^j be the total consumption of manufactures by country or region j,

$$C_m^j = \int_{D^w} C_m^j(z)dz . \qquad (33)$$

In the absence of trade barriers, the composition of consumption baskets of manufactured goods are the same in all countries and regions. Consequently, the imports of country j from the rest of the OECD are

$$M_{oe}^j = (1 - s^{rw} - s^j)C_m^j, \quad j = 1, \ldots, n . \qquad (34)$$

The imports of the rest of the world from the OECD are

$$M_{oe}^{rw} = (1 - s^{rw})C_m^{rw} . \qquad (35)$$

To obtain total trade within the OECD, we sum the expressions for M_{oe}^j in (34) to obtain

$$M_{oe}^{oe} = \sum_{j=1}^n M_{oe}^j = \left(1 - s^{rw} - \sum_{j=1}^n (s^j)^2 / (1 - s^{rw})\right) C_m^{oe} . \qquad (36)$$

Table 1 presents the shares of OECD income accounted for by each member country in 1990. Since we assume that all countries in the OECD are identical except for their size, this share also represents the share of OECD production of manufactured goods accounted for by each country.

3. Calibration

In this section we describe the calibration of the model to a 1990 data set. We begin by assembling a benchmark data set for the OECD in 1990. Specifically, we aggregate figures on production and factor utilization for each of the 3 sectors in the model for the 23 countries listed in Table 1.

The 1990 OECD data set is presented in Table 2. The figures for GDP in each of the 3 sectors are taken from OECD *National Accounts*. To obtain the factor inputs, we first obtain a labor compensation share for the OECD,

$$\frac{\sum_{i=p,m,s} H_i^{oe}}{\sum_{i=p,m,s} Y_i^{oe}} = \frac{\sum_{j=1}^{23} LC^j}{\sum_{j=1}^{23} (LC^j + FC^j + OS^j - UP^j)}. \tag{37}$$

Here LC^j is the total labor compensation in country *j; FC^j* is fixed capital consumption; OS^j is operating surplus; and UP^j is unincorporated profits. What this procedure does is to split indirect taxes and unincorporated profits, which is mostly returns to self-employed workers or family businesses, proportionally between returns to labor and returns to physical capital. We then proportionally adjust the labor compensations for each of the 3 sectors reported by OECD *National Accounts* so that their total yield the labor compensation implied by relation (34). Imports of primaries by the OECD from the rest of the world are taken from OECD *Foreign Trade by Commodity*. The number reported is that for net imports. We also report results for an alternative calibration in which these imports are gross exports, 275,043 million U.S. dollars, rather than 192,641 million U.S. dollars. The results for this alternative calibration do not differ significantly from those reported in the next section. Net exports of manufacturing from the OECD to the rest of the world are set equal to imports of primaries to insure balanced trade. Notice though that, given product differentiation in manufacturing, the OECD both imports manufactured goods from the rest of the world and exports manufactured goods to it. The data on consumption by sector are obtained residually. Notice that the concept of consumption in the model corresponds to consumption plus investment plus government spending in the national income accounts.

Population figures are taken from UN *World Population Project*. They are

$$N^{oe} = 853.7, \quad N^{rw} = 4,428.3. \tag{38}$$

where the units are millions of people.

Total income in the rest of the world is taken from UN *Yearbook of National Accounts Statistics*. In our model this figure is also equal to total consumption:

$$\sum_{i=p,m,s} Y_i^{rw} = \sum_{i=p,m,s} C_i^{rw} = 5,829,270. \tag{39}$$

Table 3 presents a benchmark data set for the rest of the world. These numbers were also derived from the UN *Yearbook of National Accounts Statistics* using the following methodology: We collect sectoral production data for any country for which such data is recorded for a year in the period 1984–1991. We use the sectoral production shares to impute sectoral production in 1990 by multiplying these shares by 1990 GDP. We are able to then impute sectoral production shares for the rest of the world and multiply these shares by total output in the rest of the world to impute sectoral outputs. The number of countries in the rest of the world for which we have sectoral output data is 103. The GDP of these countries in 1990 is 3,149,703 million U.S. dollars, which is 54.0 percent of total GDP in the rest of the world.

The value of $\rho = 0.8333\ (=1/1.2)$ is chosen so that the markups charged by manufacturing firms over variable costs in the Lerner condition (18) is 20 percent. (This is consistent with evidence presented by Morrison (1993) and Martins, Scarpetta, and Pilat (1996). We normalize $d^w = 100$. The choice of any other value of d^w proportionally scales up or down F, $c_m^j(z)$, $C_m^j(z)$, and $Y_m^j(z)$, but leaves the values of all other variables unchanged.

We calibrate the model by normalizing $q_p = q_m(z) = q_s = r = w = 1$ and then calculating values of K^{rw} and H^{rw} so that the benchmark data set is an equilibrium of the model. In numerical experiments in which we allow for nonhomothetic preferences, we can use the different consumption shares in the OECD and the rest of the world to calibrate the utility parameters γ_p and γ_p. The calibration procedure yields a rest of the world that is more capital abundant than the OECD,

$$\frac{K^{rw}}{H^{rw}} > \frac{K^{oe}}{H^{oe}} \tag{40}$$

because the rest of the world needs to export the capital intensive good, primaries. This relative capital abundance is consistent with the limited data on sectoral labor shares in the UN *Yearbook of National Accounts Statistics*. It is also consistent with the evidence presented by Trefler (1993).

4. Numerical Experiments

In our numerical experiments, we introduce changes in the parameters of the model to simulate the world in 1961. The principal facts about 1961 that we incorporate into our model are that the world was a much poorer place than in 1990 and that the distribution of income and consumption of manufactured goods was much more concentrated than in 1990. Part of this concentration was reflected in the fact that the industrialized world, which we assume to be the OECD, consisted of fewer countries. Our model says that these differences will have effects on the volume and direction of trade.

In 1961 the OECD consisted of the 19 countries listed in Table 4. Notice the absence of Japan and the very large share of income generated by the United States.

The world was much poorer in 1961 than it was in 1990 for two reasons: first, endowments of factors were smaller; and, second, total factor productivities in the different sectors were lower. We begin with total factor productivities by rescaling the constants θ_i and the fixed costs F in the production functions,

$$\theta_{p,1961} = \theta_{p,1990} \tag{41}$$

$$\theta_{m,1961} = \theta_{m,1990} / 1.014^{29},\ F_{m,1961} = F_{m,1990} / 1.014^{29} \tag{42}$$

$$\theta_{s,1961} = \theta_{s,1990} / 1.005^{29} \tag{43}$$

The yearly total factor productivity growth rates, 0, 0.014, and 0.005, are those obtained by Echevarria (1997) for the OECD.

Population figures, again taken from the UN *World Population Project,* are

$$N_{1961}^{oe} = 536.0, \quad N_{1961}^{rw} = 2,545.0\,. \tag{44}$$

We calibrate the four endowments, K_{1961}^{oe}, H_{1961}^{oe}, K_{1961}^{rw}, K_{1961}^{rw}, so the following four conditions are satisfied

$$\frac{\left(\sum_{i=p,m,s} Y_{i,1990}^{oe}\right)/N_{1990}^{oe}}{\left(\sum_{i=p,m,s} Y_{i,1961}^{oe}\right)/N_{1961}^{oe}} = 2.4003 \tag{45}$$

$$\frac{\left(\sum_{i=p,m,s} Y_{i,1990}^{rw}\right)/N_{1990}^{rw}}{\left(\sum_{i=p,m,s} Y_{i,1961}^{rw}\right)/N_{1961}^{rw}} = 2.0550 \tag{46}$$

$$\frac{K_{1961}^{oe}}{H_{1961}^{oe}} = \frac{K_{1990}^{oe}}{H_{1990}^{oe}} \tag{47}$$

$$\frac{q_{p,1961}(Y_{p,1961}^{rw} - C_{p,1961}^{rw})}{\sum_{i=p,m,s} q_{i,1961} Y_{i,1961}^{rw}} = 0.0503\,. \tag{48}$$

The yearly growth rates used in (45) and (46), 0.03065 for the OECD and 0.02515 for the rest of the world, are derived from various issues of the World Bank *World Development Report*. Unfortunately, these growth rates are calculated for real GDP data that are chained in a complicated way, rather than based on a fixed base year's prices. An alternative is to compute growth rates for real GDP per capita based on 1961 prices, with

$$\frac{\sum_{i=p,m,s} q_{i,1961} Y_{i,1990}^{oe} / N_{1990}^{oe}}{\sum_{i=p,m,s} q_{i,1961} Y_{i,1961}^{oe} / N_{1961}^{oe}} = 2.4739\,, \tag{49}$$

for example. Yet another possibility would be to take the growth data for the OECD in (42) as given, but to replace the growth data for the rest of the world (43) with the requirement that

$$\frac{\sum_{i=p,m,s} q_{i,1961} Y_{i,1961}^{oe}}{\sum_{i=p,m,s} q_{i,1961} Y_{i,1961}^{rw}} = 2.9851\,, \tag{50}$$

which says that the ratio of OECD to rest of the world GDP, at 1961 prices, should equal that observed in the data. Results for numerical experiments with this alternative calibration are reported in the next section. They do not differ significantly from those reported here.

Requirement (47) — that the capital/labor ratio in the OECD stays fixed — has no significant effect on our results given the other requirements that we are imposing. Requirement (48) says that net exports of primaries from the rest of the world to the OECD should equal their observed value in 1961, taken in this case from GATT. As we have already explained it is equally possible to calibrate the model to reproduce gross exports as a faction of GDP, which were 0.081632 rather than 0.050285. The next section also presents an experiment in which we require, rather than satisfying (48), that

$$\frac{K^{rw}_{1961}}{H^{rw}_{1961}} = \frac{K^{rw}_{1990}}{H^{rw}_{1990}}. \tag{51}$$

Although the results for this alternative calibration are slightly more favorable to the new trade theory, they also imply that the rest of the world should have been a net importer of primaries in 1961, a result drastically at odds with the data.

Table 5 reports the results of some numerical experiments with our model. We focus first on the base line experiment in which $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$. It is this experiment that is the best test of the Helpman-Krugman explanation of the expansion of trade volume. Notice that, although trade between OECD countries as a fraction of GDP does expand by 25.8 percent, this increase is far short of the 111.5 percent increase in the data. Notice too that trade within the OECD increases only by 30.9 percent compared to OECD trade with the rest of the world, rather than increasing by 87.1 percent as in the data. The Helpman-Krugman explanation of the increase in trade volumes, embodied in this experiment falls well short of accounting for the facts.

Let us now focus on the experiments in which utility is nonhomothetic. Notice that, when we calibrate the parameters γ_p and γ_s to match the consumption shares in Tables 2 and 3, setting $\gamma_p = -169.5$, $\gamma_s = 314.7$, we obtain parameters that are consistent with other evidence that it is services that have the highest income elasticity of demand, followed by manufactures, which are in turn followed by agriculture. As we can see, Markusen's (1986) story does indeed go a long way in accounting for the increase in OECD-OECD trade compared to OECD trade with the rest of the world, accounting for almost half of the observed increase.

The next experiment, in which $\gamma_p = -169.5$, $\gamma_s = 314.7$, and $\eta = 0.5586$, shows that, if we introduce price elasticities of demand that differ from 1 by letting η differ from 0, the model is indeed flexible enough to account for the increase of OECD-OECD trade compared to OECD GDP. The value of η that we use is very high, however: Estimations based on multi-country panel data find values of η between -9 and -1 (see Stockman and Tesar (1995) and van Wincoop (1999), for example). Notice too that this parameterization results in a huge increase in the share of manufactures in production in the OECD over the period 1961–1990 as their relative price falls because of technological progress. This huge increase in share is very much at odds with the decline observed in the data.

The final two experiments show that, for reasonable values of η, the model is capable of matching the decline in GDP share of manufactures while preserving the explanation for the expansion of OECD-OECD trade relative to OECD trade with the rest of the world. In these numerical experiments the new trade theory fails to account for any of the increase in the ratio of OECD-OECD trade to OECD GDP.

5. Sensitivity Analysis

This section reports the results of numerical experiments of models in which we employ alternative calibration methodologies. First, we report the results of experiments where, rather than calibrating the utility parameters γ_p and γ_s to match observed consumption shares, we set them arbitrarily to $\gamma_p = -100$ and $\gamma_s = 1600$. These parameter values make services more superior than in our base case calibration. One defense for this alternative specification is that the data in Table 3, upon which our calibration of the parameters γ_p and γ_s is based, are probably the least reliable numbers in our benchmark data set.

Notice in Table 6 that the results for both the ratio of OECD-OECD trade to GDP and the ratio of OECD-OECD trade to OECD-RW trade improve significantly. Even so, in the third and fourth experiments, where η takes on reasonable values, the model is only able to replicate a small fraction of the observed increase in the ratio of OECD-OECD trade to OECD GDP. How far can we go in manipulating the parameters γ_p and γ_s to try to replicate the observed increase in the ratio of OECD-OECD trade to GDP for reasonable values of η? Not much further — this is about as favorable as we can make the results look with the functional form for utility (4) because, if we increase γ_s or decrease γ_p by any noticeable amount, we hit a corner solution for consumption of services in the rest of the world in 1960. Nevertheless, no matter what the value of η, Markusen's (1986) story based on inferiority of primaries can account for the observed increase in the ratio of OECD-OECD trade to OECD trade with the rest of the world if utility is sufficiently nonhomothetic.

Table 7 reports the results of numerical experiments of a model in which imports of primary goods by the OECD from the rest of the world are identified with gross exports, rather than with net exports as in the base case calibration. Notice that the results do not differ in any significant way from those for the base case calibration in Table 5.

Table 8 reports the results of a set of numerical experiments for the calibration in which growth in the endowments of the rest of the world between 1961 and 1990 are calibrated to replicate the observed ratio of OECD income to income in the rest of the world in 1961 (50), rather than to replicate the observed growth rate (46). Similar calculations, not reported here, show that imposing growth rates based on 1961 prices (49) do not significantly affect the results.

The final set of results for the sensitivity analysis reported in Table 9 are for numerical experiments of a model in which endowments in the rest of the world in 1961 are required to have the same capital/labor ratio as they do in 1990 (51) rather than to generate the observed exports of primaries to the OECD (48). Notice that this calibration results in the rest of the world importing primary goods from the OECD in 1961.

6. Some Not So Recent Trade Facts

Although the three facts reported in the introduction do indeed characterize post World War II trade data, they do not characterize data before then. The historical data cast doubt on the explanations of the facts posited by the new trade theory.

The high rates of growth in foreign trade and the steady increase in the ratio of trade to income observed after the 1950s, also characterized the trends in the foreign trade statistics during the nineteenth century. In fact, as reported by Kuznets (1967), between 1800 and 1913, per capita world trade grew at an average rate of 33.0 percent per decade, whereas per capita world income did it at an average rate of 7.3 percent. As a result, during the period, the ratio of trade to income increased to over 11 times its initial level. Since estimates for 1913 show that the ratio of world exports to world income was about 17 percent, in 1800 it must have been below 2 percent. The inter war period, however, resulted in a dramatic reduction in trade, not only as a fraction of world income, but also in absolute terms. This reduction was particularly intense during the Great Depression years. United Nations data show that by 1950 the ratio of world trade to world income had fallen to less than 8 percent. By 1990, this ratio had risen to slightly more than 15 percent, still not at the level achieved in 1913.

Data for the United States show a similar pattern. Starting in the 1960s, as Figure 2 reports, there was a significant increase in the ratio of trade to income but only to reach, in 1990, a level similar to those seen during the second half of the nineteenth century. (The data in this figure calculate trade as exports plus imports.)

Finally, looking at directions of trade, Woytinsky and Woytinsky (1955) report that Europe dominated world trade during the nineteenth century. In 1913 the ratio of intra European trade to world trade was 40 percent. By 1938, however, it had fall to 29 percent, and in 1953 it was 22 percent. During the next thirty years this ratio increased steadily until reaching 38 percent in 1990, a value similar to the one seen in 1913.

7. Intermediate Goods?

Our model does not include intermediate goods. Yet much of the increase in trade has been in intermediate goods. (See, for example, Feenstra, 1998.) Could introducing intermediate goods be a way of rescuing the implications of the new trade theory for the growth of trade? To answer this question, we develop a model with intermediate goods.

The crucial step in terms of theory is to modify the production functions for primaries (10), manufactures (12), and services (11) to be

$$Y_p^j = \min\left[\frac{X_{pp}^j}{a_{pp}}, \frac{\int_{D^w} X_{mp}^j(z)dz}{a_{mp}}, \frac{X_{sp}^j}{a_{sp}}, \theta_p \left(K_p^j\right)^{\alpha_p} \left(H_p^j\right)^{1-\alpha_p}\right] \tag{52}$$

$$Y_m(z) = \min\left[\frac{X_{pm}^j(z)}{a_{pm}}, \frac{\int_{D^w} X_{mm}^j(z,z')dz'}{a_{mm}}, \frac{X_{sm}^j(z)}{a_{sm}}, \theta_m \left(K_m(z)\right)^{\alpha_m} \left(H_m(z)\right)^{1-\alpha_m} - F\right] \tag{53}$$

$$Y_s^j = \min\left[\frac{X_{ps}^j}{a_{ps}}, \frac{\int_{D^w} X_{ms}^j(z)dz}{a_{ms}}, \frac{X_{ss}^j}{a_{ss}}, \theta_s \left(K_s^j\right)^{\alpha_s} \left(H_s^j\right)^{1-\alpha_s}\right] \tag{54}$$

Here, for example, $X_{mp}^j(z)$ is the intermediate input of the manufactured good produced by firm z into the production of primaries in country or region j. This sort of production function — where intermediate goods enter in fixed proportions is the typical functional form used in applied general equilibrium trade models. (See, for example, Kehoe and Kehoe 1995.) Notice that in the production function for manufactures (53), we are assuming that fixed costs use up labor and capital but not intermediate goods.

We now need to modify the market clearing conditions (26), (27), and (28):

$$\sum_{j=1}^{n,rw}\left(C_p^j + X_{pp}^j + \int_{D^j} X_{pm}^j(z)dz + X_{ps}^j\right) = \sum_{j=1}^{n,rw} Y_p^j \tag{55}$$

$$\sum_{j=1}^{n,rw}\left(C_m^j(z) + X_{mp}^j(z) + \int_{D^j} X_{mm}^j(z',z)dz' + X_{ms}^j(z)\right) = Y_m(z), \quad z \in D^w \tag{56}$$

$$C_s^j + X_{sp}^j + \int_{D^j} X_{sm}(z)dz + X_{ss}^j = Y_s^j, \ \ j = 1,...,n,rw. \tag{57}$$

The crucial step in terms of calibration is to develop an input-output matrix for the OECD in 1990. Such a matrix is presented in Table 10. There were five steps involved in calculating this matrix:

1. We form a 9x9 intermediate transactions matrix for the United States in 1992 by taking the 1992 U.S. summary use matrix and distributing the Noncomparable Imports row proportionally across the Agricultural Products, Minerals, and Manufacturing Products rows.

2. We multiply each of the 9 rows of the 1992 intermediate transactions matrix by the ratio of the 1990 gross output deflator to the 1992 gross output deflator for the relevant sector. We then multiply each column of this matrix by the ratio of intermediate inputs to value added in that sector in 1990 divided by the ratio of intermediate inputs to value added in that sector in 1992. This gives us a matrix of intermediate inputs in 1990 prices.

3. We aggregate the 9 rows and columns of this intermediate transactions matrix into 3 rows and columns — primaries, manufactures, and services.

4. We multiply each of the 3 columns of the resulting matrix by the ratio of 1990 GDP in the OECD in Table 2 to the 1990 GDP in the United States in that sector.

5. We divide the intermediate inputs of primaries into manufactures by 2. Without this adjustment the consumption of primaries in the OECD is 1990 is so small that we are

unable to calibrate the utility function in the numerical experiment with endogenous to replicate the observed consumption patterns in the OECD and the rest of the world.

6. We calculate consumption of the good produced by sector i by the requirement that the total expenditures by that sector be equal to the total revenue of that sector.

The crucial hypothesis that we make in calculating the data in Table 10 is that the production technology throughout the OECD — and indeed throughout the whole world —was the same in 1990 as it was in the United States. Given the way that we are calculating consumption, the effect of reducing the intermediate inputs of primaries into manufactures is to reassign these inputs to consumption of primaries and to reduce the consumption of manufactures by the same amount. Most primary goods that are consumed are subject to processing that reclassifies them as manufactured goods. The 1992 2-digit use matrix shows that more than 88 percent of primary inputs into manufacturing sectors are made up of agricultural inputs into Food and Kindred Products, Tobacco Products, and Lumber and Wood Products and of crude petroleum inputs into Petroleum Refining and Related Products, for example. Numerical experiments not reported here indicate that our results are not very sensitive to the choice of how much consumption of manufactures to reclassify as consumption of primaries as long as it is enough so that we can calibrate the model so that β_m is nonnegative.

We now report the results of the same numerical experiments of the model with intermediate goods as we have performed for the model without intermediate goods in Table 5. The only new elements in the model are the production functions with intermediate goods (52), (53), and (54). We need to decide whether technological progress only increases the total factor productivity of capital and labor θ_i or if it also lowers the unit input requirements for intermediate goods a_{ij}. Table 11 reports the results of the numerical experiment for the model that keeps the unit input requirements for intermediate goods fixed. As before, the model can explain, at best, only a small fraction of the increase in trade that has occurred between 1961 and 1990 if we assign the elasticity parameter η a reasonable value.

Calibrating the model with intermediate goods is difficult because of the lack of comparable input-output matrices across countries and across time. How reasonable is our assumption that unit input requirements for intermediate goods stayed fixed between 1961 and 1990? For the United States we only have comparable data on inputs and outputs by sector since 1977. Nevertheless, these limited data suggest that unit input requirements have, in fact, fallen over time. Figure 3 shows the ratios of real intermediate inputs divided by real gross output over the period 1977-1990. Putting a reduction in unit input requirements between 1961 and 1990 into the model makes it even more difficult to generate increases in trade. To see this, let us extrapolate the changes in intermediate input requirements observed between 1977 and 1990:

$$a_{ip,1961} = 1.0121^{29} a_{ip,1990} \tag{58}$$

$$a_{im,1961} = 1.0041^{29} a_{im,1990} \tag{59}$$

$$a_{is,1961} = 0.9977^{29} a_{is,1990} . \tag{60}$$

Table 12 presents the results for the numerical experiments with this model. Notice the dramatic drops in trade between 1961 and 1990 for reasonable values of elasticity the parameter η. For this particular calibration, the results show that the expansion of trade is even more of a puzzle than it is when we ignore intermediate goods.

Intermediate goods are disproportionately used by and produced by the manufacturing sector. In the United States in 1992, for example, although the manufacturing sector accounted for 18.2 percent of GDP, it accounted for 39.6 percent of the use of intermediate goods and 35.7 percent of their production. A decline in the importance of intermediate goods as a share of production will be reflected in a decline in the importance of manufactures and a resulting fall in the importance of trade. It does not seem that introducing intermediate goods, by itself, can rescue the implications of the new trade theory for the growth of trade. It would be worthwhile to explore the implications of different functional forms for the production functions (52), (53), and (54). It would also be useful to examine input-output matrices for other countries. A brief look at different input-output matrices confirms the impression that intermediate goods are disproportionately used by and produced by the manufacturing sector. In Mexico in 1985, for example, although the manufacturing sector accounted for 23.4 percent of GDP, it accounted for 52.3 percent of the use of intermediate goods and 41.7 percent of their production.

Putting intermediate goods into our analysis still leaves us with the same mystery in relation to the new trade theory: The goods that are being traded more and more over time are the same goods whose importance is falling in relationship to domestic production.

8. Policy?

The years after World War II have seen substantial steps towards global trade liberalization. Could it be changes in policy rather than the features emphasized in the new trade theory that have been responsible for the dramatic increase in the ratio of trade to income? We can provide a preliminary answer to this question and highlight the issues at stake with a simple version of the new trade theory model used in this paper.

Consider a model with only one sector, the manufacturing sector, and one set of countries that engage in international trade, the OECD. Suppose that each of the n countries in the OECD imposes trade barriers on imports from the other countries in the form of a uniform *ad valorem* tariff, τ. In contrast to our earlier analysis, we assume that all of the countries in the OECD are identical in terms of size, because trade barriers would affect countries of different size differently. In this model, each country would produce the fraction $1/n$ of the world's varieties of goods. Let C_d be the amount of each variety consumed domestically and C_f the amount consumed in each of the $n-1$ foreign countries. Symmetry and the first order conditions for utility maximization imply that

$$\frac{C_d}{C_f} = (1+\tau)^{\frac{1}{1-\rho}} \tag{61}$$

Market clearing implies that

$$C_d + (n-1)C_f = Y \tag{62}$$

The consumer's budget constraint implies that

$$C_d + (n-1)(1+\tau)C_f = Y + T \tag{63}$$

where $T = (n-1)\tau C_f$ is tariff revenue and $Y + T$ is GDP. Combining these conditions, we obtain an expression for the ratio of exports to GDP:

$$\frac{(n-1)(1+\tau)C_f}{Y+T} = \frac{n-1}{(n-1)(1+\tau)+(1+\tau)^{1/(1-\rho)}} \tag{64}$$

To replicate the index of size distribution of national incomes in the OECD, $\left(1-\sum_{j=1}^{n}(s^j)^2\right)$, with symmetric countries where $s^j = 1/n$, we can let the number of countries take on non integer values. In 1961, $\left(1-\sum_{j=1}^{n}(s^{j})^{2}\right)$ = 0.6634, implying that n = 2.97. In 1990, $\left(1-\sum_{j=1}^{n}(s^{j})^{2}\right)$ = 0.8272, implying that n = 5.79. As we have seen, however, the change in the size distribution of national incomes is almost exactly canceled out by the decline in the importance of the manufacturing sector. Consequently, we fix n = 5.79 and ask whether changes in trade barriers as represented by τ can account for the more than doubling of the ratio of trade to income. The answer to this question obviously depends on how much trade barriers have fallen and on the elasticity of substitution between varieties, $1/(1-\rho)$. Calculations for a wide variety of parameters are presented in Figure 4. What we need is a large fall in trade barriers, accompanied by a large elasticity of substitution. If $\rho = 1/1.1$, for example, implying an elasticity of substitution of 11, a fall in τ from 0.20 to 0.05 implies that the ratio of trade to income increases by a factor of 2. If $\rho = 1/1.2$, however, implying an elasticity of substitution of 6, we need a larger fall in τ, say from about 0.35 to 0.05 to produce the same sort of increase in the ratio of trade to income.

Yi (2003) argues that, since average tariff rates have fallen from about 15 percent in 1960 to 5 percent in 1990, incorporating policy changes into the new trade theory cannot account for the increase in trade unless we assume very high elasticities of substitution in varieties. He presents a model in which it is increases in international vertical integration, induced by changes in trade policy, that account for the increase in the ratio of trade to product. It must be pointed out, however, that a large number of non-tariff barriers to trade have been increasingly used since the 1960s. To the extent that these trade barriers have fallen significantly, a version of the new trade model that emphasizes trade policy may be capable of explaining large increases in the ratio of trade to income. Yet, the evidence with respect to their quantitative importance as a barrier to trade is mixed, as shown, for example, by Harrigan (1993), Hummels (1990), and Laird and Yeats (1990).

Data Sources

We report the sources for all data used in the paper ordered as they are presented.

Indices of output and exports for 1950–1990 in Figure 1:
United Nations, *Statistical Yearbook,* New York, various issues.

World exports and world GDP for 1950, 1970 and 1990:
United Nations, *Trends in International Distribution of Gross World Product, Special Issue, National Account Statistics,* New York, 1993.

Trade within the OECD and OECD trade with the rest of the world for 1961–1990:
Organization for Economic Cooperation and Development, *Foreign Trade by Commodities,* volumes 1 and 2, Paris, various issues.

Grubel-Lloyd indices for 1990:
Organization for Economic Cooperation and Development, *Foreign Trade by Commodities,* volumes 1 and 2, Paris, 1993.
United Nations, *International Trade Statistics Yearbook,* New York, 1993.

GDP for each OECD country in Tables 1 and 4 and sectoral GDP and labor and capital for the OECD in Table 2:
Organization for Economic Cooperation and Development, *National Accounts,* Paris, various issues.

Net and gross imports of primaries by the OECD from the rest of the world for 1990 in Table 2:
Organization for Economic Cooperation and Development, *Foreign Trade by Commodities,* volume 1, Paris, 1993.

Population for the OECD and the rest of the world in 1990 and 1961:
United Nations, *World Population Project,* New York, various issues.

Aggregate and sectoral GDP for the rest of the world in 1990 in Table 3:
United Nations, *Yearbook of National Account Statistics,* New York, 1993.

Income per capita growth rates for the OECD and the rest of the world for 1961–1990:
World Bank, *World Development Report,* Washington, various issues.

Net exports of primaries from the rest of the world to the OECD in 1961:
General Agreement on Tariffs and Trade, *International Trade,* Geneva, 1963.
International Monetary Fund, *Direction of Trade Annual,* Washington, 1965.

Exports, imports, and GNP for the United States for 1870–2000 in Figure 2:
Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970,* Washington, 1975.
Department of Commerce, Bureau of Economic Analysis, http://www.bea.doc.gov/bea.

Historical data on world trade:
S. Kuznets, "Quantitative Aspects of the Economic Growth of Nations: X-Levels and Structure of Foreign Trade: Long-term Trends," *Economic Development and Cultural Change,* Part II, 1967.
United Nations, *Trends in International Distribution of Gross World Product, Special Issue, National Account Statistics,* New York, 1993.

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W. S. Woytinsky and E. S. Woytinsky, *World Commerce and Governments: Trends and Outlook,* The Twentieth Century Fund, New York, 1955.
International Monetary Fund, *Direction of Trade Statistics Yearbook,* Washington, various issues.

Intermediate inputs and GDP in the United States and Mexico in Figure 3:
Instituto Nacional de Estadística, Geografia e Informática, *Anuario Estadístico de los Estados Unidos Mexicanos,* Aquascalientes, various issues.
Department of Commerce, Bureau of Economic Analysis, "Improved Estimates of Gross Product by Industry 1947–98," *Survey of Current Business,* **81** (2000). The data are available on the Bureau's website, http://www.bea.doc.gov/bea.

Input-output matrices for the United States and Mexico:
Instituto Nacional de Estadística, Geografia e Informática, *Matriz de Insumo Producto Actualizada a 1985,* Mexico, D. F., 1990.
Department of Commerce, Bureau of Economic Analysis, "Input-Output Accounts of the U.S. Economy, 1987," *Survey of Current Business,* **74** (1994). The data are available on the Bureau's website, http://www.bea.doc.gov/bea.

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Table 1

OECD in 1990

Country	Share of GDP (percent)
Australia	1.7884
Austria	0.9685
Belgium/Luxembourg	1.2529
Canada	3.4492
Denmark	0.7941
Finland	0.8185
France	7.2584
Germany	9.9581
Greece	0.5034
Iceland	0.0380
Ireland	0.2764
Italy	6.6422
Japan	18.0338
Netherlands	1.7224
New Zealand	0.2617
Norway	0.7010
Portugal	0.4098
Spain	3.0043
Sweden	1.3951
Switzerland	0.1725
Turkey	0.9150
United Kingdom	5.9231
United States	33.7234

Table 2

Benchmark 1990 OECD Data Set

(Million U.S. Dollars)

	Primaries	Manufactures	Services	Total
H_i^{oe}	228,208	2,883,736	8,643,962	11,755,906
K_i^{oe}	440,785	775,558	3,497,331	4,713,674
Y_i^{oe}	668,993	3,659,924	12,141,293	16,469,580
C_i^{oe}	861,634	3,466,653	12,141,293	16,469,580
$Y_i^{oe} - C_i^{oe}$	−192,641	192,641	0	0

Table 3

Benchmark 1990 Rest of the World Data Set

(Million U.S. Dollars)

	Primaries	Manufactures	Services	Total
Y_i^{rw}	1,222,748	1,159,518	3,447,005	5,829,270
C_i^{rw}	1,030,107	1,352,159	3,447,005	5,829,270
$Y_i^{rw} - C_i^{rw}$	192,641	−192,641	0	0

Table 4

OECD in 1961

Country	Share of GDP (percent)
Austria	0.7496
Belgium/Luxembourg	1.2487
Canada	4.2210
Denmark	0.6960
France	6.9943
Germany	9.7086
Greece	0.5043
Iceland	0.0274
Ireland	0.2095
Italy	4.6421
Netherlands	1.3719
Norway	0.5970
Portugal	0.3222
Spain	1.3751
Sweden	1.6151
Switzerland	1.0697
Turkey	0.8255
United Kingdom	8.0829
United States	55.7392

Table 5

Results for Base Case Calibration

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
1. $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.1078	0.1357	25.8%
OECD-OECD Trade/OECD-RW Trade	0.8927	1.1685	30.9%
OECD Manf GDP/OECD GDP	0.2230	0.2222	–0.4%
2. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.1032	0.1322	28.1%
OECD-OECD Trade/OECD-RW Trade	0.7386	1.0603	43.6%
OECD Manf GDP/OECD GDP	0.2254	0.2222	–1.4%
3. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0.5586$			
OECD-OECD Trade/OECD GDP	0.0625	0.1322	111.5%
OECD-OECD Trade/OECD-RW Trade	0.7378	1.0603	43.7 %
OECD Manf GDP/OECD GDP	0.1366	0.2222	62.7%
4. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.1184	0.1322	11.7%
OECD-OECD Trade/OECD-RW Trade	0.7389	1.0603	43.5%
OECD Manf GDP/OECD GDP	0.2586	0.2222	–14.1%
5. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.1184	0.1322	1.6%
OECD-OECD Trade/OECD-RW Trade	0.7391	1.0603	43.5%
OECD Manf GDP/OECD GDP	0.2841	0.2222	–21.8%

Table 6

Results for Alternative Specification of Nonhomotheticity

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
2. $\gamma_p = -100$, $\gamma_s = 1600$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.0785	0.1079	37.5%
OECD-OECD Trade/OECD-RW Trade	0.3140	0.5886	87.4%
OECD Manf GDP/OECD GDP	0.2303	0.2222	–3.5%
3. $\gamma_p = -100$, $\gamma_s = 1600$, $\eta = 0.5510$			
OECD-OECD Trade/OECD GDP	0.0510	0.1079	111.5%
OECD-OECD Trade/OECD-RW Trade	0.3137	0.5886	87.6%
OECD Manf GDP/OECD GDP	0.1451	0.2222	53.1%
4. $\gamma_p = -100$, $\gamma_s = 1600$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.0889	0.1079	21.4%
OECD-OECD Trade/OECD-RW Trade	0.3141	0.5886	87.4%
OECD Manf GDP/OECD GDP	0.2624	0.2222	–15.3%
5. $\gamma_p = -100$, $\gamma_s = 1600$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.0969	0.1079	11.4%
OECD-OECD Trade/OECD-RW Trade	0.3142	0.5886	87.3%
OECD Manf GDP/OECD GDP	0.2869	0.2222	–22.6%

Table 7

Results for Gross Imports Calibration

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
1. $\gamma_p = 0, \gamma_s = 0, \eta = 0$			
OECD-OECD Trade/OECD GDP	0.1094	0.1357	24.0%
OECD-OECD Trade/OECD-RW Trade	0.9029	1.1685	29.4%
OECD Manf GDP/OECD GDP	0.2254	0.2222	–1.4%
2. $\gamma_p = -134.6, \gamma_s = 418.0, \eta = 0$			
OECD-OECD Trade/OECD GDP	0.1005	0.1291	28.4%
OECD-OECD Trade/OECD-RW Trade	0.6433	0.9757	51.7%
OECD Manf GDP/OECD GDP	0.2297	0.2222	–3.3%
3. $\gamma_p = -134.6, \gamma_s = 418.0, \eta = 0.5675$			
OECD-OECD Trade/OECD GDP	0.0610	0.1291	111.5%
OECD-OECD Trade/OECD-RW Trade	0.6422	0.9757	51.9%
OECD Manf GDP/OECD GDP	0.1395	0.2222	59.3%
4. $\gamma_p = -134.6, \gamma_s = 418.0, \eta = -1$			
OECD-OECD Trade/OECD GDP	0.1147	0.1291	12.6%
OECD-OECD Trade/OECD-RW Trade	0.6437	0.9757	51.6%
OECD Manf GDP/OECD GDP	0.2622	0.2222	–15.3%
5. $\gamma_p = -134.6, \gamma_s = 418.0, = -9$			
OECD-OECD Trade/OECD GDP	0.1258	0.1291	2.6%
OECD-OECD Trade/OECD-RW Trade	0.6441	0.9757	51.5%
OECD Manf GDP/OECD GDP	0.2872	0.2222	–22.6%

Table 8

Results for Alternative RW Growth Calibration

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
1. $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.1102	0.1357	23.1%
OECD-OECD Trade/OECD-RW Trade	0.9901	1.1685	18.0%
OECD Manf GDP/OECD GDP	0.2217	0.2222	0.2%
2. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.1048	0.1322	26.1%
OECD-OECD Trade/OECD-RW Trade	0.7877	1.0603	34.6%
OECD Manf GDP/OECD GDP	0.2244	0.2222	–1.0%
3. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0.5613$			
OECD-OECD Trade/OECD GDP	0.0625	0.1322	111.5%
OECD-OECD Trade/OECD-RW Trade	0.7872	1.0603	34.7%
OECD Manf GDP/OECD GDP	0.1339	0.2222	65.9%
4. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.1204	0.1322	9.8%
OECD-OECD Trade/OECD-RW Trade	0.7880	1.0603	34.6%
OECD Manf GDP/OECD GDP	0.2580	0.2222	–13.9%
5. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.1324	0.1322	–0.2%
OECD-OECD Trade/OECD-RW Trade	0.7883	1.0603	34.5%
OECD Manf GDP/OECD GDP	0.2837	0.2222	–21.7%

Table 9

Results for Alternative Endowment Calibration

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
RW Prim Exp/RW GDP	0.0503	0.0330	–34.3%
1. $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.1077	0.1357	26.0%
OECD-OECD Trade/OECD-RW Trade	0.8922	1.1685	30.9%
OECD Manf GDP/OECD GDP	0.2226	0.2222	–0.2%
RW Prim Exp/RW GDP	0.0488	0.0330	–32.4%
2. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.0935	0.1322	41.4%
OECD-OECD Trade/OECD-RW Trade	0.7214	1.0603	47.0%
OECD Manf GDP/OECD GDP	0.2058	0.2222	8.0%
RW Prim Exp/RW GDP	–0.0280	0.0330	–
3. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0.4886$			
OECD-OECD Trade/OECD GDP	0.0625	0.1322	111.5%
OECD-OECD Trade/OECD-RW Trade	0.7203	1.0603	47.2%
OECD Manf GDP/OECD GDP	0.1376	0.2222	61.4%
RW Prim Exp/RW GDP	–0.0352	0.0330	–
4. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.1090	0.1322	21.3%
OECD-OECD Trade/OECD-RW Trade	0.7220	1.0603	46.9%
OECD Manf GDP/OECD GDP	0.2398	0.2222	–7.3%
RW Prim Exp/RW GDP	–0.0244	0.0330	–
5. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.1209	0.1322	9.3%
OECD-OECD Trade/OECD-RW Trade	0.7226	1.0603	46.7%
OECD Manf GDP/OECD GDP	0.2658	0.2222	–16.4%
RW Prim Exp/RW GDP	–0.0216	0.0330	–

Table 10

Benchmark 1990 OECD Data Set

(Million U.S. Dollars)

	Primaries	Manufactures	Services	Total
X_{pj}^{oe}	208,154	401,397	260,642	870,193
X_{mj}^{oe}	127,470	3,604,068	1,484,417	5,215,955
X_{sj}^{oe}	217,661	2,038,989	4,442,776	6,699,426
H_{j}^{oe}	228,208	2,883,736	8,643,962	11,755,906
K_{j}^{oe}	440,785	775,558	3,497,331	4,713,674
Y_{j}^{oe}	1,222,278	9,703,748	18,329,128	29,255,154
C_{j}^{oe}	544,726	4,295,152	11,629,702	16,469,580
$Y_{j}^{oe} - C_{j}^{oe} - X_{jp}^{oe} - X_{jm}^{oe} - X_{js}^{oe}$	−192,641	192,641	0	0

Table 11

Results for Model with Intermediate Goods

No Technological Progress in Intermediate Inputs

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
1. $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.3085	0.3704	20.1%
OECD-OECD Trade/OECD-RW Trade	1.0128	1.3097	29.3%
OECD Manf GDP/OECD GDP	0.2487	0.2222	–10.7%
2. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.3051	0.3701	21.3%
OECD-OECD Trade/OECD-RW Trade	0.9970	1.3052	30.9%
OECD Manf GDP/OECD GDP	0.2490	0.2222	–10.8%
3. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = 0.7852$			
OECD-OECD Trade/OECD GDP	0.1750	0.3701	111.5%
OECD-OECD Trade/OECD-RW Trade	1.0384	1.3052	25.7%
OECD Manf GDP/OECD GDP	0.1439	0.2222	55.4%
4. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.3233	0.3701	14.5%
OECD-OECD Trade/OECD-RW Trade	0.9940	1.3052	31.3%
OECD Manf GDP/OECD GDP	0.2634	0.2222	–15.6%
5. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.3374	0.3701	9.7%
OECD-OECD Trade/OECD-RW Trade	0.9331	1.3052	39.9%
OECD Manf GDP/OECD GDP	0.3066	0.2222	–27.5%

Table 12

Results for Model with Intermediate Goods

Technological Progress in Intermediate Inputs

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.0531	0.1123	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8435	1.5786	87.1%
OECD Manf GDP/OECD GDP	0.2948	0.2222	–24.6%
1. $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.3498	0.3704	5.9%
OECD-OECD Trade/OECD-RW Trade	1.0063	1.3097	30.2%
OECD Manf GDP/OECD GDP	0.2535	0.2222	–12.3%
2. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.3385	0.3701	9.3%
OECD-OECD Trade/OECD-RW Trade	0.9114	1.3052	43.2%
OECD Manf GDP/OECD GDP	0.2542	0.2222	–12.6%
3. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = 0.7710$			
OECD-OECD Trade/OECD GDP	0.1750	0.3701	111.5%
OECD-OECD Trade/OECD-RW Trade	0.8252	1.3052	58.2%
OECD Manf GDP/OECD GDP	0.1368	0.2222	62.4%
4. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.3701	0.3701	0.0%
OECD-OECD Trade/OECD-RW Trade	0.9204	1.3052	41.8%
OECD Manf GDP/OECD GDP	0.2765	0.2222	–19.6%
5. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.3951	0.3701	-6.3%
OECD-OECD Trade/OECD-RW Trade	0.9267	1.3052	40.8%
OECD Manf GDP/OECD GDP	0.2940	0.2222	–24.4%

Figure 1

World Trade and World GDP

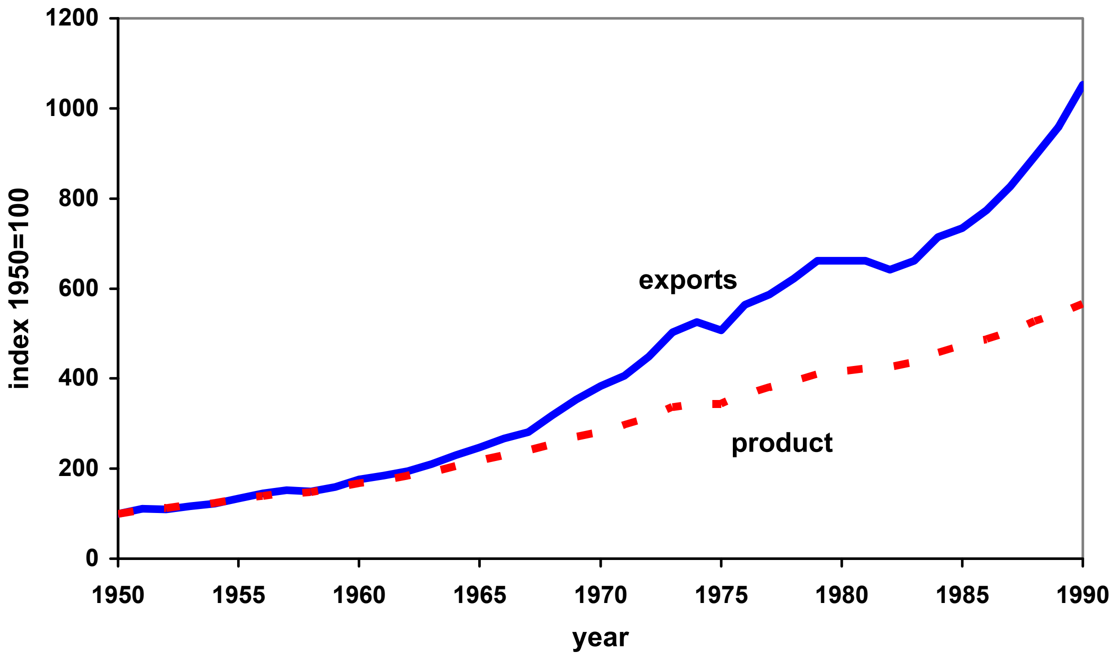

Figure 2

U.S. Trade as a Fraction of U.S. GNP

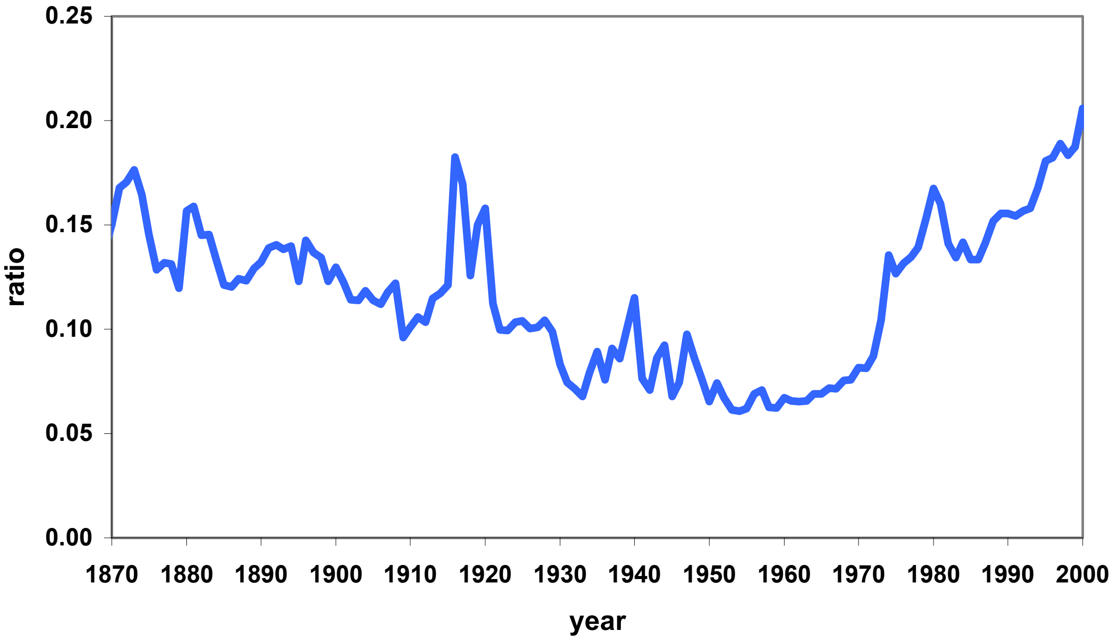

Figure 3

Real Intermediate Inputs / Real Gross Output

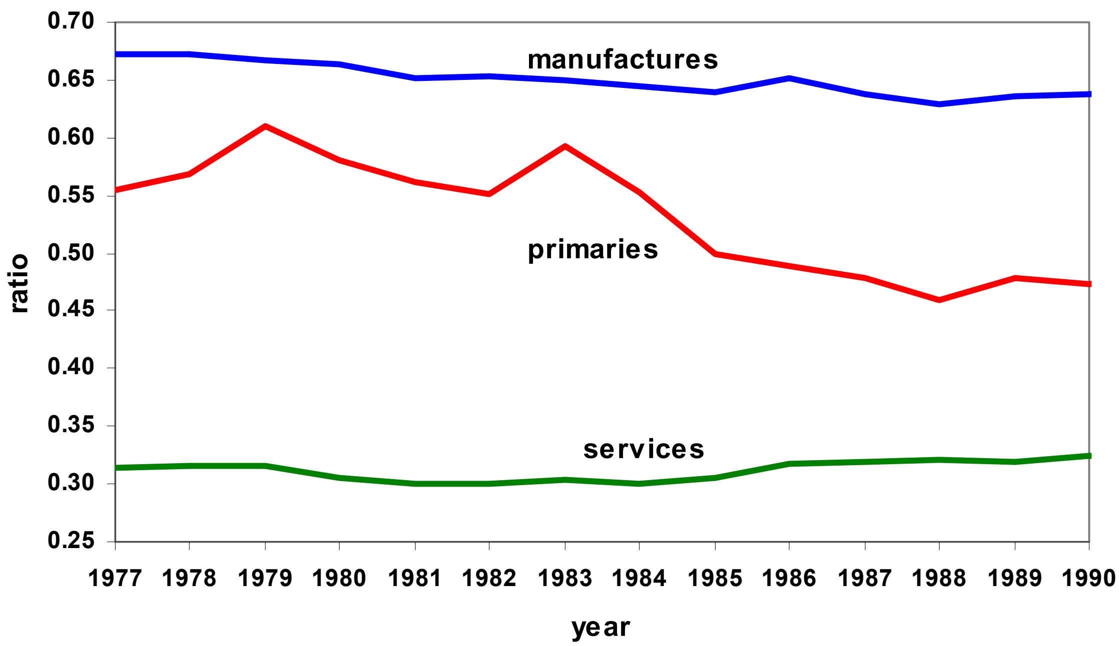

Figure 4

World Trade as a Fraction of World GDP