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Edward E. Leamer
James Levinsohn

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ABSTRACT

This paper provides a critical look at recent empirical work in international trade theory. The paper addresses the issue of why empirical work in international trade has perhaps not been as influential as it could have been. The paper also provides several suggestions on directions for future empirical research in international trade.

Edward E. Leamer
Anderson Graduate School of Management
University of California, Los Angeles
Los Angeles, CA 90024
and NBER

James Levinsohn
Department of Economics
University of Michigan
Ann Arbor, MI 48109-1220
and NBER

International Trade Theory: The Evidence

Edward E. Leamer
UCLA
National Bureau of Economic Research
and
James Levinsohn
University of Michigan
National Bureau of Economic Research

1. Introduction

International microeconomics is primarily a theoretical enterprise that seems little affected by empirical results. ''How can this be?'', we ask ourselves. After all, trade flows have been measured with greater accuracy over longer periods of time than most other economic phenomena. One might have guessed that these rich trade data bases would have yielded findings that materially affected the way that international economists think. But with a few notable exceptions, they have not. Some might argue that we don't really have very much useful data. Rather, we have reams of noisy data drawn from extremely complex non-experimental settings that are very imperfectly understood so we shouldn't be expecting very much from these data.

We can hardly review the empirical work in international economics with such a defeatist premise, and we prefer to think that the fault lies elsewhere. First of all, the data have not really been very accessible. Fortunately, technological change is making the dissemination of large data bases much less costly. To assist in that dissemination, we have listed in the Appendix some of the most important data sources.

Our review is premised, however, on the idea that we have not done the job right. If we examined the data correctly, and reported the findings persuasively, then data would have a much more substantial impact. Thus in the midst of the summaries of methods and findings, we will insert many comments and ideas about why the results have ended up to be fairly unimportant. There are two main messages we hope to convey.

We would like to thank Robert Feenstra Bob Staiger, and Dan Trefler for suggestions. Special thanks to Alan Deardorff and Gene Grossman for their very detailed comments and suggestions.

The first message is: "Don't take trade theory too seriously." In practice, this means "Estimate, don't test." Estimate the speed of arbitrage, don't test if arbitrage is perfect and instantaneous. Understand that theorems are neither true nor false. They are sometimes useful and sometimes misleading. If we approach a data base with the contrary attitude, hoping to determine the verity or falsity of a theorem, we may statistically "reject" the theory, but leave it completely unharmed nonetheless. After all, we already knew it wasn't literally true.

"Estimate, don't test" is important advice, but it can be taken too far when empirical analysis is done without benefit of a clear theoretical framework. Our second piece of advice points in the opposite direction: "Don't treat the theory to casually." In practice this means: "Work hard to make a clear and close link between the theory and the data." We are convinced from several notable failures that it is important to have clear linkages between the theory and the data if empirical results are to have any hope of having a lasting impact. High partial correlations by themselves are not enough. We need a good story.

Our failures in linking theory with data, either too closely or too loosely, come in part from our excessive specialization. Some economists imagine the data (theorists), some imagine how to analyze imagined data (econometric theorists), some collect the data (usually government statisticians), and others analyze the data (applied econometricians). It seems healthier to us if we collectively make more of an effort to bridge the gaps between these distinct functions. Better communication between theorists and data analysts would be helpful. For example, we think it would be extremely valuable if international trade theorists attempted to connect aspects of their theories to observable phenomenon by indicating what data would shake their faith in the usefulness of the theory that they present.

Of course, not all useful theory is linkable to observable phenomena. Proofs of the static gains of trade fall into the unrefutable category yet these are some of the most important results in all of economics. But this extraordinary success of theory without data should not be taken as a license for the creation of an unlimited array of theories that are completely without any possible connection with observables. On a case by case basis, we need to ask what function the theory is serving, beyond mathematical amusement.

For instance, when the Law of Comparative Advantage is expressed in terms of a comparison of price vectors in autarky and trade, and when autarky prices are completely unobservable, we must ask what this theory is all about. When a theory is completely dependent on the number of goods and the number of factors being equal, we need to be told how to count factors and goods. When it is demonstrated that a production frontier has flats of dimension equal to the number of goods minus the number of factors, we need to know what observable phenomenon would make us think the real world closely approximates this abstract model.

While it would be helpful for theorists to think about data, it would also be helpful for data analysts to develop more of a ''feel'' for theory. Many data analysts do not understand that theories are designed to serve a single limited purpose. The proper function of empirical work is not to test the validity of the theory but to determine if the theory is working adequately in its limited domain. International trade in lumber might be well characterized by a factor endowments-based model, while an endogenous growth model might better explain trade patterns in computer memory chips, and a model of monopolistic competition might best characterize international trade in varieties of furniture.

Data analysts need to understand also that distinct theories that are intended for use in different limited domains cannot properly be mixed together in a multiple regression in the absence of a generalizing theory that covers multiple domains. Frequently in the literature we review, empirical work takes a grab-bag approach with variables intended to capture features of different theories thrown together in a multiple regression. But the theories may have no content outside their own domains, and may bear no meaningful relationship with the conditional correlations that come rolling out of multiple regression packages. Many of the empirical studies on international trade and monopolistic competition reviewed in section 4 are examples of this grab-bag approach.

With these guiding principles in mind, we turn to reviewing the recent empirical literature on "testing" trade theories and "estimating" the relative importance of different sources of comparative advantage. In our review, we have placed heavier emphasis on newer work and refer the reader to Deardorff (1984) for a review of older work. We have also tried to go beyond just reviewing the literature and, on several occasions, suggest possibly fruitful but as yet unexplored research topics and strategies. This review is organized around the sources of comparative advantage ordered by intellectual chronology: technological differences in Section 2, factor proportions in Section 3, competitive strategies in Section 4, demand biases in Section 5 and distance in Section 6. Section 7 provides a brief discussion of some of the data sources often used in the empirical international trade literature as well as possibly useful but less well exploited data sources.

2. Empirical Studies of the Ricardian and Ricardo-Viner Models

The Ricardian and the Ricardo-Viner models point to technological differences as the source of international comparative advantage. A simple Ricardian model has one input, labor, which is assumed to be mobile across the two sectors of the economy, but internationally immobile. The Ricardo-Viner model introduces into the model two additional factor which are sector-specific. This gives curvature to the production possibilities curve and also allows international commerce to affect the distribution of income. Although there is little or no direct empirical support for these simple models, there is nonetheless growing awareness that technological differences are a natural consequence of economic isolation and play a role in the integration process following an economic liberalization.

2.1 The Ricardian Model

In 1817, David Ricardo developed the now familiar model with two countries, two goods, and a single input, labor. Ricardo demonstrated the remarkable result that both countries can gain from trade if their (constant) labor input ratios differed, even if one country had an absolute advantage in both goods. The intellectual power of the model lies in its simplicity, but this same simplicity causes great difficulties when one tries to translate the theory into predictions that might be worth exploring in real data sets. The real skill in doing empirical work is the wise separation of those aspects of a theory that have empirical content from those that do not. Below we discuss three Ricardian propositions that might or might not fall into the ''empirically relevant'' category.

Except when labor input requirements are identical across countries, there exist gains from trade. This proposition has been the focus of much theoretical analysis. Using revealed preference arguments, theorists such as Ohyama (1972) and Dixit and Norman (1986) have shown that this proposition is quite general, and the proposition is not restricted to just the Ricardian model. Though obviously important and theoretically robust, the existence of gains from exchange is fundamentally a premise of economics, not a testable implication of a particular model. Some studies use the competitive paradigm as a foundation for measuring the gains from trade, some studies have connected growth with openness, but none has connected static gains from trade with openness.

The observed terms of trade are bounded between the comparative labor cost ratios of the two countries. The existence of gains from market exchanges is a theoretically sturdy result, derivable from widely differing kinds of assumptions. But the Ricardian link between comparative cost ratios and the terms of trade is quite fragile, hardly surviving even the generalization to the multi-good case. Moreover, any serious attempt to study the determinants of relative product prices would surely allow for other inputs including physical and human capital. We are inclined therefore to think of this result as a mathematical toy. It is great fun to have it in our play-pens but it has little to do with economics outside the play-pen.

A country exports the commodity in which it has a comparative labor cost advantage and imports the commodity in which it has a comparative disadvantage. The Ricardian link between trade patterns and relative labor costs is much too sharp to be found in any real data set. A weaker but also theoretically fuzzy link was uncovered by some of the first studies of comparative advantage by MacDougall (1951) and Balassa (1963). These studies are reviewed in Deardorff (1984). We are unaware of any recent work testing or estimating the applicability of the Ricardian model.

Aside from the three propositions just listed, the Ricardian model is an important reminder that technological differences can be a source of comparative advantage. However, the Ricardian one-factor model is a very poor setting in which to study the impacts of technologies on trade flows, because the one-factor model is just too simple. Below, we discuss how technological differences have been incorporated into empirical studies of the Heckscher-Ohlin model, thereby capturing the content of the Ricardian model but not the detail.

2.2 The Ricardo-Viner Model

The Ricardo-Viner model has one mobile factor, typically labor, that is used economy-wide and a set of sector-specific factors. The sector-specific factors can be interpreted as technological inputs, in which case the Ricardian model and the Ricardo-Viner model are very similar, differing only in an assumption about the constancy of the marginal productivity of labor. In a dynamic model, the sector-specific factors can be allowed to be mobile over time, thereby producing in the long run a Heckscher-Ohlin equilibrium. This transformation has been examined in theoretical papers by Neary (1978) and Mussa (1974).

A dynamic version of a multi-factor Ricardo-Viner model is a natural theoretical foundation for a study of a panel data set with observations of trade flows or production levels over time. The empirical work of which we are aware is almost exclusively cross-sectional, with separate models estimated for each time period. Though the Ricardo-Viner model has been much neglected empirically, we expect it to be employed extensively when analysts turn to the study of panel data.[1]

3. The Heckscher-Ohlin Model

The Heckscher-Ohlin model has served as the backbone of traditional trade theory for almost 60 years. This model identifies a mapping from exogenously given factor supplies and exogenously given external product prices (determined in the international marketplace) into internal factor prices, output levels and consumption levels, the difference between these last two items being international trade. Although the two sets of exogenous variables and the three sets of endogenous variables can be used to form six sets of partial derivatives, four of these have been selected for special attention, theoretically and empirically. The Rybczynski Theorem connects output levels with factor supplies; the Stolper- Samuelson Theorem connects factor prices with product prices; the Factor Price Equalization Theorem connects factor prices with factor supplies; and the Heckscher-Ohlin Theorem connects trade with factor supplies. Each of these has been subjected to some empirical examination which we review in this section. (The relationship between consumption levels and product prices has been extensively studied in a largely separate literature, e.g. Deaton (1992)). The other general equilibrium relationship-- between either output levels or trade on the one hand and product prices on the other-- has not been examined empirically, possibly because the only price variability allowed in the simple static models comes from trade barriers, which are not enormously variable across countries and which are extremely difficult to measure. Interest in dynamic models is likely to generate increased attention to the relationship between output levels (or commodity composition of trade) and product prices.

[1] Grossman and Levinsohn (1989) find evidence suggesting that capital is sector-specific. While this is consistent with the Ricardo-Viner model, it is also consistent with other models in which capital is sector specific.

3.1 The Rybcyzinski Theorem

The Rybcyzinski Theorem relates changes in endowments to changes in the pattern of production. In particular:

The 2x2 Rybczynski Theorem: Holding product prices fixed, an increase in the quantity of one factor will give rise to a more than proportional increase in the output of the good which uses that factor intensively and a reduction of the output of the other good.

According to the two-factor two-good Rybczynski theorem. The positive derivative is no surprise; the negative derivative is a surprise. At least one negative derivative for each factor occurs also for higher dimensional models.

It isn't altogether clear how one should approach the Rybczynski theorem empirically. The result seems to allow four different levels of interpretation:

1. Total current factor supplies matter. History does not.

2. The relationship between outputs and factor supplies is homothetic.

3. The relationship is linear.

4. At least one Rybczynski derivative is negative.

Cross-section studies by their very nature take as given the lack of historical persistence. This seems unfortunate since real output levels have a high degree of persistence over time. We expect that increased interest in dynamics is likely to have a large effect on empirical analysis of this result and many other ones as well.

Homotheticity is an important property and deserves to be examined carefully since scale effects in these output functions would suggest either increasing returns to scale or non-competitive behavior, both of which leave scope for ameliorative government trade interventions which can only cause inefficiencies in an HO model.

Linearity is highly specific to the model with equal numbers of factors and goods, and does not seem worth taking seriously.

The negative derivative might seem like a curiosum, but we think that it is actually a very important property. What is really at stake here is not the Rybczynski Theorem but rather its travelling companion, the Factor Price Equalization Theorem. These results together imply that factor supply changes, such as waves of migrants, do not have much affect on factor prices because the potential affect on factor prices is dissipated by product mix changes in favor of the products that use the accumulating factor intensely. If one cannot find much association between product mix and factor supplies, one suspects that the factor price equalization theorem is not operating properly either. A negative derivative is precisely the kind of extreme result that would tend to lend credence to the FPE theorem.

Data bases for studying the Rybczynski Theorem are difficult to come by. Natural experiments that might be worth looking at include the inflow of over half a million immigrants from the former Soviet Union to Israel, a country with a population of only about 5 million, and the reallocation of relative factor endowments in recently unified Germany. Since the Rybczynski Theorem is a result about the pattern of production, empirical work directly addressing the theorem requires production data. The OECD has a fairly complete data base on production (and other variables) at the 3-digit ISIC level. Regressions explaining these production levels as functions of national factor endowments can be found in Leamer (1993a) and Harrigan (1993). Using a panel of 20 countries over 15 years and country specific fixed effects, typical estimated regressions reported by Harrigan are:

$$\text{Iron and Steel}: \; y = 0.824\,\text{Capital} - 2.311\,\text{SkilledLabor} - 0.590\text{UnskilledLabor}$$

$$\text{Printing and Publishing}: \; y = 0.570\,\text{Capital} + 1.089\,\text{SkilledLabor} - 0.529\text{UnskilledLabor}$$

with t-statistics (in absolute value) between 2 and 3.5 for each estimated coefficient. Land is excluded from the fixed effects regressions since it does not vary over time within a country. From results like these, Harrigan infers that capital is a source of comparative advantage in these industries, while skilled labor is a source of comparative advantage in printing and publishing, but not in Iron and Steel. Unskilled labor is a source of comparative disadvantage in both. (Notice the negative coefficients!) Most of his results are similarly sensible. He finds that the coefficients on capital are generally robust to different specifications while those on labor are not. These results are not that different from Leamer (1984b) findings for trade flows.

Rybczynski derivatives for two-digit manufacturing sectors in U.S. SMSA's have been estimated by Leamer (1987) who finds that labor supplies, if treated as exogenous and immobile across cities, do seem to have an impact on the SMSA output composition. Leamer also finds that while the smaller SMSA's as a group have their full share of most of the manufacturing sectors, individual small SMSA's tend to have more concentrated product mixes than large SMSA's. This suggests indivisibilities, not agglomeration effects. In the econometric language, the discovery is heteroscedasticity, not nonlinearities.

3.2 The Stolper-Samuelson Theorem

The Stolper-Samuelson theorem describes a mapping from prices determined externally in international markets to prices determined internally in local markets. The result applies if the external markets determine prices of commodities and the internal markets determine prices of factors, but the framework applies also when some factors are traded internationally and some goods are not. For empirical studies, it isn't usually obvious which markets are global and which are local. Capital, for example, is sometimes thought to be traded in global markets, but Feldstein and Horioka (1980) have argued that there is a strong ''home bias'' of savings. (See the chapter in this volume by Rogoff and Obstfeld for a discussion of the evidence on this.) Because of the impact that distance has on costs, most commodity prices have important local components of variability as well as global components.

The Stolper-Samuelson theorem was originally developed in a model with two traded goods and two non-traded factors.

The 2x2 Stolper Samuelson Theorem: An increase in the relative price of a good yields an increase in the real return to the factor used intensively in that good and a decrease in the real return to the other factor.

Just as is the case with the two-good Ricardian model, "two-ness" is not an aspect of the model that is sensibly transferred into the empirical arena. To get to the real message of the result, we must accordingly read between the lines, and express results that are not dependent on two-ness. Here are some possible interpretations:

Winners and Losers Corollary: When a relative price changes, there is at least one winner and at least one loser.

Factor/Industry Detachment Corollary: External price changes have an effect on the return to a factor regardless of the industry in which the factor happens to be employed.

Scarce Factor Corollary 1: A scarce factor is helped by trade barriers; an abundant factor is hurt.

Scarce factor Corollary 2: If a factor is ``scarce enough'' it will be helped by trade barriers.

The winners and losers corollary was really the main message of the original Stolper/Samuelson paper. Contrary to widely held opinion, free trade is not good for everyone. This winners and losers corollary is true in higher dimensional models with equal numbers of goods and factors (Ethier (1984)) and, if properly stated, is true for uneven models also (see Deardorff (1994)). The Factor-Industry Detachment Corollary is a direct consequence of the assumption of an integrated internal factor market, but it is worth stating the result explicitly since it contrasts with the prediction of a specific-factors model which finds some support in research reviewed below.

The first Scarce Factor Corollary is not true in higher dimensional cases, but the second is true (see Leamer (1994)).

These corollaries can be said to be implicit but there is another important message that is communicated by its absence from the above list of interpretations:

Price Signal / Price Response Corollary: Global "shocks" are communicated to local markets through price changes, not quantity changes. The response to this price signal is a price response, not a quantity response.

This Price Signal Corollary is substantially at odds with a number of studies by labor economists and others who have attempted to estimate the impact of globalization on U.S. wages and U.S. employment levels taking as the measure of globalization the increase in the quantity of imports or the increase in the U.S. external deficit. This is discussed in more detail below. Also, see the chapter in this volume by Robert Feenstra.

These results have been used as a theoretical foundation for two different kinds of empirical exercises. Some studies examine the validity of these results, and other studies use the framework to estimate the impact of external events on internal factor markets. We review each of these in turn.

3.2.1 Political Coalitions and the Stolper-Samuelson Theorem:

The validity of the Stolper-Samuelson framework has been examined using a "revealed preference approach" by Magee (1980) and by Rogowski (1987). Magee noted that the Stolper-Samuelson theorem implies that: ``1) Capital and labor in a given industry will oppose each other on the issue of protection (or free trade) for that industry; 2) For the country as a whole, each factor will favor either free trade or protection, but not both; and 3) The position taken by capital or labor in an industry on the issue of protection will be independent of whether the industry is export or import competing.'' These three implications are tested by using data on the lobbying position of labor unions (proxying labor) and on the lobbying position of manufacturers' trade associations (proxying capital) taken from their Congressional testimony with regard to the Trade Reform Act of 1973. A stark but representative result is given by the following table.

If the Stolper-Samuelson theorem were correct, positions toward free trade should not depend on the factor's industry of employment, and capital and labor should always be in opposition to one another. In terms of Table 1, all industries would be in one of the off-diagonal cells. But in only 2 of the 21 industries (petroleum and tobacco) do management and labor have opposing positions. Magee argues that his results are much more supportive of a specific-factors model. Magee's other tests are also broadly supportive of this view.

Unlike Magee's results, Rogowski's are very supportive of the Stolper-Samuelson theorem. Rogowski uses the Stolper Samuelson framework ingeniously to discuss the political coalitions that have formed historically among land owners, capitalists and laborers, including the German "marriage of iron and rye," U.S. and Latin American populism, and Asian socialism. Perhaps the difference between Magee's negative findings and Rogowski's positive ones comes from the time frame that is implicit in their data. Magee's industrial attitudes data seem inherently short-run, whereas party affiliation studied by Rogowski is a much longer run phenomenon. May we conclude that the Ricardo-Viner model is useful for the short run, and the Heckscher-Ohlin model is useful for the long run?

3.2.2 Product Prices and Wages:

One possible source of increased income inequality in the United States and elsewhere is increased competition from low- wage developing countries. The Stolper-Samuelson theorem and the Factor Price Equalization theorem establish one foundation for a study of the impacts of international competition on wages. These results together imply that changes in the international marketplace are communicated through relative price changes and only through relative price changes.

In this section we first review work that is explicitly based on the Stolper-Samuelson Theorem and that attempts empirically to estimate the link between product prices and factor prices. Next we review work based on a partial equilibrium model which links changes in import prices to wages (and employment) by sector. Later, in the discussion of the Factor Price Equalization, we will discuss attempts to link quantity measures of global shocks (like the level of imports) to wages.

A. General Equilibrium Approaches.

Unfortunately, it doesn't take much disaggregation to get to a Stolper-Samuelson system that will overwhelm any real data set. But in a highly aggregated system, O'Rourke and Williamson (1992) find substantial support for Ohlin's hypothesis that equalization of commodity prices in the U.S. and Europe was a major source of factor price convergence in the last half of the nineteenth century. Chipman (1977) attempts to tackle the high-dimensional case, mapping external prices into internal German prices, but this paper seems to get bogged down in the econometric treatment of the data deficiency. Leamer (1994) and Leamer (1993a) attack the dimensionality problem indirectly. Instead of estimating the Stolper-Samuelson derivatives, he estimates the Rybczynski derivatives using cross country comparisons of output mix and factor supplies. Then, by appealing to the duality theorem, these Rybczynski derivatives are treated as Stolper- Samuelson derivatives.[2]

Baldwin and Cain (1994) exploit the general equilibrium nature of the Heckscher-Ohlin model to investigate possible influences on the returns to skilled labor, unskilled labor, and capital. Letting p_j denote the proportional change in the price of industry j's product, w_i the proportional change in the return to factor i, and θ_{ij} the distributive share of the ith factor in the production of the jth good (where $\sum \theta_{ij} = 1$), Baldwin and Cain make use of the fact that in the Heckscher-Ohlin model, $p_j = \sum \theta_{ij} w_i$. They estimate the following stochastic version:[3]

[2] Lawrence and Slaughter (1980) assert and Deardorff and Hakura (1993) conjecture that the duality result cannot be applied in models with more goods than factors, but Leamer (1994) shows how, in such a model, the dimensionality of price variability is restricted to the dimensionality of the factor space. For price variability so restricted the Stolper-Samuelson derivatives are well defined and the Samuelson duality theorem still applies.

[3] This same equation serves as a foundation for Leamer's(1994) reexamination of Lawrence and Slaughter's(1993) contention that globalization has not much affected wages.

$$p_j = w_{un}\theta_{unj} + w_{sk}\theta_{skj} + w_k\theta_{kj} + e_j.$$

where θ_{unj}, θ_{skj}, and θ_{kj} are the factor shares of unskilled labor, skilled labor, and capital for the jth industry while the analogous w's are the estimates of the proportional changes in the respective factor returns. The w's are estimated. Baldwin and Cain then examine whether the estimated w's are different in sign from the actual changes and whether these relationships are changing over the 1967-1992 time span. They note that, ''Should the regressions over a particular time period yield estimates of proportional changes in wages that correspond in sign with the actual changes over the period, one can conclude that the observed factor price changes are consistent with price changes that could have been brought about by changes in relative factor endowments domestically or in other factors affecting domestic or foreign prices besides technological change. One could then examine related data on domestic endowment changes and on other non-technological factors that can affect domestic and foreign prices as well as data on terms of trade improvements, shifts in the output of skilled labor-intensive goods relative to unskilled-labor intensive goods, and changes in the use of skilled versus unskilled labor in industries in an effort to narrow down the likely causes of the observed factor price changes.'' Baldwin and Cain's results suggest that foreign competition has not been a big influence on the increased wage gap between skilled and unskilled workers in the U.S.

B. Partial Equilibrium Approaches.

Many other studies of globalization and wages have taken a partial equilibrium perspective connecting price changes in an industry with wage and employment changes in the same industry. These studies are substantively in conflict with the Stolper-Samuelson framework since they do not estimate spill-overs of the price change in one industry on wages in another industry. Among the first of these studies was Grossman (1987) who estimates the impact of international competition, proxied by industry-level import price indexes, on wages and employment in nine U.S. manufacturing industries.

The basic problem confronting Grossman and several of those who have tackled this problem since is decomposing the many influences on domestic wages in a sensible and theoretically consistent way. Grossman specifies a simple structural model and then estimates the reduced form equations that result from solving out for wages in terms of the exogenous variables. His estimating equation for industry i is given by:

$$logw_{it} = \beta_0 + \beta_1\, trend + \beta_2 logK_{it}^{agg} + \beta_3 logL_t^{agg} + \beta_4 logP_t^e + \beta_5 log(P_{it}^*(1+\tau_{it})) + \beta_7 logQ_t + \epsilon_t.$$

where w_{it} is the wage in industry i in year t, K^{agg} and L^{agg} are aggregate capital and labor, P^e is the price of energy, P_{it}^* is the import price index for industry i, and Q is GNP. The coefficient β_5 measures how much import prices affect domestic wages in that industry. This regression is run separately for each of the nine industries, and a similar regression is run with employment instead of wages as the dependent variable. Grossman finds that the elasticities of domestic wages with respect to import prices are very small and often statistically insignificantly different from zero. Using simulations based on his estimated coefficients, he shows that in only two of the nine industries do wages fall by more than ten cents an hour due to increases in import competition over his sample period. While Grossman does not provide confidence intervals, ignoring co-variance terms it appears that he would be unable to reject the hypothesis that import competition had no effect on wages in any of the industries studied. Wages moved around, but import competition played a negligible role in this phenomenon. Grossman takes this as evidence of ''a fairly high degree of labor mobility out of declining sectors, at least in the long run (i.e. after eighteen months.)'' This high degree of mobility is an essential feature of the Stolper-Samuelson theorem. What is lacking, however, is a treatment of the other essential feature: cross-industry elasticities.

Grossman found that the employment effects of import competition were more substantial (but again imprecisely estimated) than the wage effects. What this implies for a theorem based on full-employment is unclear. With only a few industries examined, one does not know whether workers switched into expanding sectors or became unemployed.

Revenga (1992) followed up on Grossman's original methodology. Sticking with the reduced form estimation approach, Revenga added two twists. First, she suggested that for a large country like the United States, import prices may be endogenously determined and hence not orthogonal to the disturbance term in the estimating regression. She adopted standard instrumental variables methods to address this concern. Her selected instruments were exchange rates and foreign production costs. She also adopted a panel data approach, essentially ''stacking'' industries and allowing for an industry fixed effect. Revenga found that, depending on the chosen specification, employment elasticities are somewhat larger than Grossman's while wage elasticities remain very small. Correcting for the endogeneity of import prices results in larger elasticities. Still, many of her key parameters are not precisely estimated. Finally, the panel treatment she adopted is questionable, since in terms of the underlying model, it seems to imply that all industries have the same production function up to an affine transformation. Revenga's results, though, are consistent with the message of Grossman's original study. Labor appears fairly mobile.

Grossman and Levinsohn (1989) look at the effect of changes in import prices on the return to capital. They are unable to adopt the methods used in studying the effects of import competition on labor since the price of capital, given by its stock market value, is determined on a very efficient and forward-looking market. Only unanticipated ''news'' about the import competition, again proxied by an industry-specific import price index, will affect the price of capital, as expected shocks have already been capitalized. Grossman and Levinsohn face the task of decomposing the change in an equity price into news about several components. They estimate the effect of import competition on the return to capital in a given industry for six import-competing industries. They find that they can reject the assumption of perfect capital mobility at the 95 percent significance level for five of the six industries studied. They show that the magnitude of the estimated coefficient on import price news is similar to what results from a static model with perfectly immobile industry capital stocks. Finally, for five of the six industries, a one standard deviation shock to the expected import price creates substantial capital gains and losses for shareholders.[4] These gains and losses are on the order of 1.4 to 3.0 percent quarterly. Hence, while Grossman and Levinsohn start out with the notion of estimating Stolper-Samuelson derivatives, their estimates also reflect (favorably) on the appropriability of a specific factors model.

3.3 The Factor Price Equalization Theorem

Labels are important since they can influence the conversation in important but unfelt ways. For example, when we call trade barriers "protection" and estimators "unbiased," our critical

[4] A related paper is Brander (1991). In that paper, Brander applies standard event study analysis to examine stock market reaction to the U.S. - Canada free trade agreement.

attitudes can diminish. Likewise when we name a result the "Factor Price Equalization" Theorem, it is unsurprising that most of us have the impression that it deals with the international equalization of factor prices. Indeed it does, but only as a corollary. A more accurate name for conveying the true meaning of the result would be the Factor Price Insensitivity Theorem, which contrasts in important ways with FPE.

Factor Price Insensitivity Theorem(FPI): Within a country, factor prices are altogether insensitive to changes in factor supplies, holding product prices fixed.

Factor Price Equalization Theorem(FPE): Factor prices are the same in different countries.

Another way of stating the Factor Price Insensitivity Theorem is that the demand for labor in an open economy is infinitely elastic. This requires that factor supply variation is too small to take the country into a different cone of specialization. Factor price equalization is a corollary requiring the additional and unlikely trio of assumptions: identical technologies, identical product mixes and no factor intensity reversals.

In addition to deflecting our attention away from the empirically more relevant FPI theorem, the traditional way of expressing FPE hides its real message. The message isn't that factor prices are equalized, or even that they are insensitive to variation in factor supplies. The message is the mechanism, namely variation in the mix of output. There might well be other mechanisms to achieve the same results, but both FPE and FPI rely on changes in the composition of output, and these results should be judged to be empirically invalid if there is no evidence that the mix of output depends on factor supplies.

Furthermore, like any other arbitrage condition, both FPI and FPE are conditions that necessarily take some time to hold, if they hold at all. Although the theories make no explicit reference to time, we all understand what is really being asserted: arbitrage works rapidly enough so that in the vast vibrating real economy we can "see" the force of arbitrage at work.

To be explicit, a dynamic version of FPI might be called Factor Price Adjustment, a version of Samuelson's Le'Chatelier Principle applied over time and also over space:

Factor Price Adjustment (FPA). The initial factor price response to an increase in a factor supply is reduced over time as the economy shifts its output mix toward sectors that employ this factor most intensively. The more open a country is to international commerce, the greater will be the opportunities for adjustment in the output mix and the less will be the factor price response at any point in time.

Expressed differently, this is saying that the derived demand for labor is more elastic in the long run than in the short run, and more elastic for an open economy than for a closed one.

A dynamic version of FPE, suggested by Samuelson (1971) in an attempt to give FPE some empirical content is

Factor Price Convergence (FPC). As barriers to international commerce diminish, factor prices converge.

Trade in goods substitutes for trade in factors. With free trade in goods, factor prices are equalized. Hence, as trade in goods becomes more free, there is a tendency for factor price differentials across trading partners to be reduced. This leads to factor price convergence. This result is related to the Stolper-Samuelson Theorem which we discuss above. Indeed, the Stolper- Samuelson theorem is usually combined with a theory of global price determination to establish FPC.

3.3.1 Empirical Studies of FPE

Given the policy importance of these results, it is surprising how little study there has been of FPI, FPE, FPC and FPA. Perhaps FPE is so obviously violated that economists feel it doesn't merit close scrutiny. After all, neither Heckscher nor Ohlin thought the result was empirically valid. Ohlin (1933) asserted: "Complete equality of factor prices is ... almost unthinkable and certainly highly improbable." In a very useful survey of FPE and associated literature, Rassekh and Thompson (1993) include similar quotations from Samuelson, Caves, Bhagwati, and Travis. If the force of authority isn't adequate, take a look at Figure 1 from Leamer (1993b) which illustrates the vast differences in wages around the globe.

[Insert figure titled ''Industrial Wages and Population'' about here.]

Each country in this figure is represented by a rectangle with height equal to wages and width equal to population, thus with area roughly proportional to GDP.

But merely to dismiss FPE as empirically invalid is a dangerous attitude that is not evident in the frequent studies of other equally invalid arbitrage conditions such as purchasing power parity. Careful study of FPE seems desirable for two reasons. First we need to know just how badly violated is this arbitrage condition. Much of the apparent differences in wages can be explained by differences in benefits, and vacations and work conditions and, most importantly, differences in skill, and it seems wise to find out how much; see e.g. Krueger (1968). More importantly, the real question isn't whether FPE is true or not. Trust us, it isn't true. The real question is what causes the violations that we observe. Is it increasing returns to scale, or technological differences, or multiple cones, or inertia, or what? Again, estimate, don't test.

We are inclined to think that factor price disparities come from three sources: differences in product mix (the multi-cone model), technological differences, and inertia. The inertia and multi-cone explanation have not received adequate attention empirically, especially in comparison with the technological explanation. The technological difference explanation harkens back to Leontief's favorite explanation of his non-paradox: in productivity equivalent units, the U.S. was labor abundant. Dollar, Baumol, and Wolff (1988) point out that a country's productivity advantages in one sector tend to be matched by productivity in other sectors, and convergence of total factor productivity over time seems to affect all sectors about the same. More recently, Trefler (see Trefler (1993) and Trefler (1994)) has made a lot of mileage out of the assumption that there are technological differences across countries, which in the HO model implies that the ratio of the factor return to factor productivity ought to be equal for a given factor across countries. Factor productivity is not observed and is inferred by assuming that the Heckscher-Ohlin-Vanek model explains trade exactly when factors are measured in productivity equivalents. In Trefler (1993), he asks, what productivity adjustment ought to be made to a factor if the H-O-V model were to fit exactly. He then examines whether these inferred productivity adjustments are consistent with observed relative factor prices.

Trefler finds evidence of neutral technological differences, although he reports that for labor there is a systematic predictive bias such that wages in the poorest countries are under-predicted while those in the richest are over-predicted. The gist of Trefler's results are well illustrated in the below figures (generated from data reported by Trefler).

If factor price equalization held exactly for these factors, then all points would lie on the diagonal line.[5] Trefler investigates reasons why the data might not fit the theory exactly, but the lasting impression is that FPE finds significant support in the data once productivity differentials have been incorporated into the analysis. Incidentally, Trefler is rejecting FPE as it is originally stated, but he is not rejecting FPI. Indeed he has presented implicitly a model in which FPE is false but FPI is valid. By the way, this finding is only the first step. Before we can place much faith in the hypothesis of systematic technological differences, we will need a lot more work to determine exactly the source of these differences. Is it infrastructure? Is it organizational forms? Or what?

3.3.2 Empirical Studies of Factor Price Insensitivity and Factor Price Adjustment[6]

The formal theory of factor price insensitivity makes explicit reference to variations of factor supplies only within a cone of diversification. Thus if FPI were taken literally, an important empirical task would be to determine the edges of the cones, beyond which factor prices and output composition changes. In fact, few empirical workers will take FPI that seriously. Most will be interested in the speed and process by which arbitrage takes place, as described by the Factor Price Adjustment Theorem. How much potential impact of a migrant flow on wages is dissipated by changes in the composition of output? How fast does this occur?

The great waves of migration that moved large numbers of workers from low-wage regions to high-wage regions form severe tests of Factor Price Insensitivity. Results are surveyed in Hatton and Williamson (1992). Did the Irish migration into Britain between the 1820s and the 1850s suppress real wages? Indeed it did. (Williamson (1990)). What about the repeated waves of migrants into the United States in the 19th and 20th century? The answer to this question seems sufficiently unclear empirically that historians have succumbed to the seduction of CGE models (e.g. O'Rourke and Williamson (1992).) What about the recent waves of migrants into U.S. cities? Borjas, Freeman, and Katz (1991) finds no discernible effect of migrants on the cross-city variation

[5] For the case of capital, the price of capital is the investment price index from the Penn World Tables.

[6] The recent great burst of academic interest in "convergence" has used the scale economies of the endogenous growth literature as an intellectual foundation, but has until recently altogether neglected the fact that countries are economically interconnected by flows of commodities, physical and knowledge capital and labor.

of wage rates in the United States. Card (1990) finds that the very large Mariel migration from Cuba had no impact on wages in Miami.

These studies by labor economists generally are concerned with the effect of the migrant flow on wages, but not the mechanism, which as we have argued is the essence of all the theorems on factor price determination discussed here. To support these results, we need to uncover a response to a migrant flow in the composition of output; we need to find evidence of the Rybczynski theorem. For example, why has apparel employment plummeted almost everywhere in this country, except in Los Angeles, where it is now practically the only industry that is experiencing growth? Isn't this the FPA theorem at work, with output responding to the Mexican migration? More on this above in our review of the Rybczynski theorem.

Hatton and Williamson (1992) (p. 54) summarize the ambiguity that this literature leaves: "We need to learn much more about these global market forces, and the complex interdependence between capital, labor and commodity markets is likely to be central to any comprehensive explanation that emerges."

3.3.3 Quantity Signal and Price Response Approaches.

The FPI theorem establishes conditions under which external or internal quantity shocks have no affect on wages. According to this result, if the relevant product prices do not change, then wages will not change even if there is international migration, or internal factor accumulation, or changes in the external deficit or increased imports. Conversely, there may be little or no change in these quantities, and if product price changes are substantial, the Stolper-Samuelson Theorem indicates that there will be a substantial wage response. In great conflict with the foregoing remarks, many studies having an informal theoretical basis proceed as if external shocks are transmitted by quantity signals, and sometimes only by quantity signals. For example, partial equilibrium equations are often estimated with wages or employment levels in an industry as the dependent variable, and with a measure of the quantity of imports in that industry as an explanatory variable. Informal general equilibrium treatments such as Freeman and Lawrence (1991) and Katz and Murphy (1992) compute the "net factor content" of trade and act as if this net factor flow were equivalent to an internal change in the factor supply. This is dangerously confusing. In a model in which Factor Price Insensitivity holds, factor supply changes have no affect on wages, so why bother with the calculation? Deardorff and Staiger (1988) offer one answer: changes in the factor content of trade may serve as a proxy for the product price changes that are the real route by which globalization is affecting wages. This relationship between changes in product prices and the factor content of trade clearly depends on technologies and tastes. Using log-linear technologies and preferences, Deardorff and Staiger are able to derive a simple expression linking changes in wages to changes in the factor content of trade, but more generally only correlation-type results are possible. This is intriguing, but not a full justification for the calculations because other sources of variation in the factor content of trade would leave wages unaffected. These include capital flows that alter the external deficit, and also changes in the factor supplies.

The Deardorff and Staiger argument requires all goods to be produced, and the factor content calculations are all the more suspect if one uses the multi-cone model and if the price changes occur only for commodities that are not produced at home. Wood (1994b) makes this point in a way by showing how much greater are the labor-service imports of the developed countries if the factor content calculation uses developing-country input intensities instead of developed.

Our conclusion: DANGER, PELIGRO

Other recent studies in labor economics that address the general issue of trade and employment include Bound and Johnson (1992), Lawrence and Slaughter (1980) and Murphy and Welch (1991, 1992). For more on wages and trade, see the review article by Deardorff and Hakura (1993).

3.4 The Heckscher-Ohlin Theorem

International trade is the difference between production and consumption. Although there has been a very substantial amount of empirical study of the commodity composition of international trade, very little of policy relevance hinges on the nature of consumption. Most of the theoretical and policy action of the general equilibrium model is on the production side, not the consumption side. Thus the study of patterns of international trade is really an indirect way to study the production side of the model: the Rybczynski Theorem, the Stolper-Samuelson Theorem, and the Factor Price Insensitivity Theorem. To accomplish this indirect study, it is traditional theoretically, and often empirically, to neutralize the consumption side by assuming identical, homothetic tastes. This makes trade behave pretty much the same as production.

The studies of the Heckscher-Ohlin model form a good case study illustrating what may happen if one tries to do empirical work without a clearly articulated theory. Time and again we will see that unsupported and even erroneous conclusions have been drawn from data sets studied without a theoretical basis.

A matrix of equations that characterize the production side of the nxn version of the Heckscher-Ohlin model is

$$Q = A^{-1}V \tag{3.1}$$

where Q is the vector of outputs, V is the vector of factor supplies, A is the input-output matrix with elements equal to the amount of a factor used to produce a unit of a good. This is just the inverted form of the factor market equilibrium conditions equating the supply of factors V to the demand for factors AQ.

The consumption side of the model is neutralized by the assumption of identical homothetic tastes. Then, in the absence of barriers to trade, all individuals face the same commodity prices, and they consume in the same proportions:

$$C = sC_w = sA^{-1}V_w \tag{3.2}$$

where C is the consumption vector, C_w is the world consumption vector, V_w is the vector of world factor supplies, and s is the consumption share. Thus trade is

$$T = Q - C = A^{-1}V - sA^{-1}V_w = A^{-1}(V - sV_w). \tag{3.3}$$

The consumption share s will depend on the level of output and also on the size of the trade balance, $B = \pi'T$, where π is the vector of external prices which in the absence of trade barriers would equal the internal prices p. Pre-multiplying (3.3) by the vector of prices π and then rearranging produces the consumption share:

$$s = \frac{\pi'A^{-1}V - B}{\pi'A^{-1}V_w} = \frac{GNP - B}{GNP_w}. \tag{3.4}$$

This is often called the Heckscher-Ohlin-Vanek model referring to Vanek's (see Vanek (1968)) use of the assumption of homothetic tastes. Using this H-O-V model, trade given by Equation

(3.3) and production given by Equation (3.1), are identical except that production takes as an input the total factor supplies, but trade uses the net factor supplies, adjusted for implicit factor consumption. For a small country with an exogenously determined level of the trade balance B proportional to GDP, the consumption share (3.4) and consequently the trade vector (3.3) are both approximately homothetic linear functions of the endowments. The more basic Heckscher-Ohlin proposition retains homotheticity but makes no reference to linearity and merely asserts that trade arises because of the unequal distribution of resources across countries. A pure H-O model thus implies that if the ratios of resources were the same in all countries then there would be no trade. Several of the assumptions listed above can be altered without affecting this basic H-O proposition. These assumptions only introduce nonlinearities in the relationship between trade and factor supplies.

Incidentally, one rather awkward assumption that cries out for change is that of equal numbers of commodities and factors. After all, we really don't know how to count either.

3..4. 1 Factor Content Studies

The first and by far the most influential study of trade patterns using the Heckscher-Ohlin model was done by Leontief (1953), who found that U.S. imports in 1947 were more capital intensive relative to labor than U.S. exports. This empirical "paradox" sparked a search of great breadth and intensity for a theory that could explain it. Among the explanations were labor skills, trade barriers, natural resource abundance, capital-biased consumption, and technological differences.

Surprise! The Leontief finding is compatible with the U.S. being capital abundant as shown in Leamer (1980). This is a good illustration of the need for a clear conceptual framework when empirical work is being carried out since in its absence substantial mistakes can be made.

One suspicious step in Leontief's calculation is that he separately computes the factor content of exports and imports, whereas the H-O-V theory relates to net exports.[7] From (3.3), the H-O-V theory implies that the factor content of trade satisfies the relationship $F = AT = V - sV_w$. From this set of equations we can separate the capital and labor content of trade: $F_K = X_K - M_K = K - sK_w$, $F_L = X_L - M_L = L - sL_w$, where X and M refer to exports and imports respectively. Leamer

[7] Note, though, that the H-O-V model did not appear until about 15 years *after* Leontief's study.

(1980) shows that the Leontief finding, that exports are less capital intensive than imports, $X_K/X_L < M_K/M_L$, is compatible with capital abundance, $K/L > K_w/L_w$.

A correct way to use the H-O-V theory to infer the relative abundance of factors from the factor content of trade refers to the factor content adjusted for the trade imbalance, $F^A = AT - V_w B/GNP_w$. Using (3.3) and (3.4) for country i, this adjusted factor content is $F_i^A = AT_i - V_w B_i/GNP_w = V_i - (GNP_i/GNP_w)V_w$. Dividing the kth element of each side by $(V_{wk})/(GNP_i/GNP_w)$ produces

$$Z_{ik} = (F_{ik}^A/V_{wk})/(GNP_i/GNP_w) = (V_{ik}/V_{wk})/(GNP_i/GNP_w) - 1 \qquad (3.5)$$

The ratio of the resource share (V_{ik}/V_{wk}) to the GNP share (GNP_i/GNP_w) of the right hand side of this expression is a measure of the abundance of factor k. On the left-hand side of this expression is the exported share of the domestic supply adjusted for the trade imbalance. Thus the theory suggests there are two ways to measure factor abundance: directly by $(V_{ik}/V_{wk})/(GNP_i/GNP_w) - 1$ or through the adjusted factor content of trade Z_{ik}. Measures of the adjusted factor content of trade Z_{ik} for the United States, the United Kingdom and Japan in 1967 using U.S. factor intensities are reported in Table 2.

The qualitative content of equation (3.5) has been studied in at least two ways: by examining the signs of the numbers Z_{ik} or their rank ordering. A Leontief type of study selects a country i and compares the numbers Z_{ik} for different factors k, say capital and labor. If $Z_K > Z_L$ where K and L refer to capital and labor, then trade reveals that the country is capital abundant compared to labor. Indeed, that is the Leamer (1980) comment on Leontief: if you do the calculation right, then the U.S. is revealed to be relatively capital abundant. This is true also for the 1967 data reported in Table 2 since the U.S. capital number of .08 percent exceeds the overall labor number of -.25 percent. According to the data in Table 2, the United States is most abundant in arable land and most scarce in forest land.

It is also possible to make comparisons across countries. The United Kingdom is more scarce in capital than Japan which is more scarce in capital than the United States. The United Kingdom is most abundant in labor, overall. Japan is scarcest in arable land.

A test of the H-O theorem compares the numbers in Table 2 with direct measures of factor abundance. Tests of this form are what Bowen, Leamer, and Sviekauskaus (1987) call rank tests since they compare the rank order of factor abundance measured directly and measured through the factor content of trade.

It is also possible to perform "sign" tests that compare the signs of the left and right of equation (3.5). This was first done by Brecher and Choudhuri (1982) who mention that a feature of Leontief's data is that the net export of labor services is positive, even after adjusting for the trade imbalance. Using the right-hand side of (3.5) this implies that the U.S. per capita GNP is less than world per capita GNP, which is impossible to square with the facts. Another way to describe sign tests is that they compare the resource abundance of one factor with an average of all the other factors, since the GNP ratio is an earnings weighted average of all the factor abundance ratios. By examining the signs in Table 2 we infer that the United States was abundant in capital, professional workers and arable land and scarce in unskilled labor. Both the United Kingdom and Japan were scarce in capital and land and abundant in labor. Sign tests would compare these signs with the corresponding signs of direct measures of the factor abundance..

Bowen et al. (1987) in a study of 1967 data on 27 countries and 12 factors find about thirty five per cent violations of the signs implied by (3.5) and about fifty per cent violations of the ranks. This seems disappointing, but what did you expect? In the absence of a clearly stated alternative theory, it seems impossible to determine just how many violations are enough to cast substantial doubt on the theory.

Beginning with Leamer and Bowen (1981), Leamer has often made the observation that the Heckscher-Ohlin model links three separately observable phenomena: trade, resource supplies and technological input coefficients. A full test of the theory accordingly must begin with separate measures of all three of these concepts and must explore the extent to which the observed data violate the H-O restrictions.

Bowen, Leamer and Sveikauskus use measurements of all three concepts and link their work to a carefully formulated model, namely the H-O-V model as captured by equation (3.5) which determines the adjusted factor content of trade as a function of resource supplies. Recognizing the impossibility of testing a theory without an alternative, these authors generalize the H-O-V model to allow (a) non-homothetic tastes characterized by linear Engel curves, (b) technological differences among countries that affect all technological coefficients proportionately and (c) various kinds of measurement errors. Hence, they do posit some alternative hypotheses. (They do not, though, consider a fixed factor model as an altogether different alternative.) In the words of Bowen et al. (1987) "The data suggest errors in measurement in both trade and national factor supplies, and favor the hypothesis of neutral technological differences across countries. However, the form of the technological differences favored by the data involves a number of implausible estimates, including some in which factors yield strictly negative outputs. Thus,... The Heckscher-Ohlin model does poorly, but we do not have anything that does better."

Brecher and Choudhri (1988) test the H-O-V model by exploiting the model's prediction that the amount of a factor embodied in a dollar of domestic expenditure should be the same for any pair of countries. In order to give the model a fighting chance, Brecher and Choudri examine data from the United States and Canada-- a country-pair for which the model's assumptions of identical tastes and technologies, free trade, and common factor prices might be expected to be fairly reasonable. The implications of the H-O-V model examined by Brecher and Choudri do not find support in the data.

Trefler (1994) revisits Bowen, Leamer, and Sveikauskus and arrives at very different conclusions. Using basically the same variables and tests as Bowen et. al. (BLS), but with data from 1983, Trefler first replicates BLS's test of the Heckscher-Ohlin-Vanek theorem. Like BLS, he finds that "it performs miserably." Trefler closely examines where the theory fits especially poorly and finds that deviations from theoretical predictions follow pronounced patterns. In particular, he finds that: 1) these deviations are correlated with country size; 2) rich (poor) countries are scarce (abundant) in almost all factors; and 3) the ratio of net factor service trade to its theoretical prediction has a very small variance across countries. Like BLS, Trefler posits modifications to the H-O-V model and asks whether the modified theory better fits the data. Trefler shows that one of the alternatives considered by BLS (neutral international technology differences) is very important when trying to explain why the standard H-O-V model performs so poorly. After correcting an error in their calculations, he finds that the HOV model with neutral technological differences "performs remarkably well." Trefler's preferred specification allows for home bias in consumption as well as neutral technological differences.

Hufbauer (1970) is a notable early study that employs measurements of trade, resource supplies, and technological input coefficients using only two-dimensional data. Some typical results are reported in Table 3.

The countries in this list are ordered by measures of their capital per person, with Canada being the most abundant in capital and Pakistan the least abundant. The capital per person in exports is compared with the capital per person in imports in the next two columns. It should be noted that the U.S. data display the ''Leontief paradox'' that imports are more capital intensive than exports. But this is not true for the other countries at the top of the list. Hufbauer reports that the capital per person overall (first column) has a correlation of .625 with the capital per person in exports (second column) and a correlation of -.353 with capital per person in imports (third column). This is regarded to be confirmatory of the H-O model: capital abundant countries tend to have capital intensive exports and labor intensive imports.

There are four comments that can be made about this study. First, the study uses measures of all three concepts: factor supplies, trade and technological input intensities. As we have already mentioned, a full test of the H-O model must surely make reference to all of these. Second, Hufbauer's analysis does not refer explicitly to any model. It separates imports from exports, which got Leontief in trouble. Third, we find it curious that the capital per person in exports varies greatly across countries in contrast to the capital per person in imports. We would not have expected this result based on our understanding of the H-O model. What might account for it? Perhaps the model with more goods than factors can help. In the H-O model with many goods and two inputs, countries can concentrate production on just two of the goods and import all the rest. The two produced goods have similar capital intensities. In words, countries have a diversified import structure but a concentrated export structure. Fourth, competing models and/or factors that might explain trade are ''tested'' by comparing the size of the correlations that they produce. Hufbauer's list of theories is noticeably inclusive: factor proportions, human skills, scale economies, stage of production, technological gap, product cycle and preference similarity.

3.4.2 Cross-commodity Comparisons

The Heckscher-Ohlin theorem has often been studied empirically with cross-commodity comparisons implicitly based on the assumption that the export performance "should" depend on the characteristics of the industry. Simple correlations were rather common early in the literature, but these gave way to multiple correlations in the 1970's.

For example, Keesing (1966) reports some simple correlations of export performance (U.S. Exports) / (Group of 14 Countries Exports) with skill intensities that are reported in Table 4.

These results are suggestive of human capital abundance in the United States because the largest positive correlations occur at the highest skill levels and because the unskilled labor share is actually negatively correlated with export performance.

A typical multiple regression from Baldwin (1971) is given in table 5.

One thing that might be concluded from this regression is that the negative sign on the capital intensity variable suggests the Leontief paradox that the United States does not export goods that are capital intensive.

More recently, Wright (1990) has used cross-industry regressions for 1879, 1899, 1909, 1914, 1928, and 1940 to track the sources of American industrial success. This study adds an interesting twist by running the cross-industry regression for multiple time periods and searching for patterns of change over time. For example, Wright finds that the capital to labor ratio is an important source of comparative advantage in the early periods, but that its coefficient becomes negative (connoting a comparative disadvantage) by 1940. Natural resources, on the other hand, do not contribute to export success in the late nineteenth century, but become increasingly important during the twentieth.[8]

It is difficult to interpret these findings without answering, implicitly or explicitly, the following difficult questions:

[8] A related study is Stern and Maskus (1981).

1) How should the export performance variable be scaled? Keesing scales by the exports of a comparison group of fourteen countries. Baldwin uses the unscaled data, which seems a bit uncomfortable since all of his explanatory variables are scaled.

2) Is it more appropriate to use simple correlations or multiple regressions?

3) How should the "importance" of a resource be inferred? By the size of the simple correlation? By the t-statistic in the multiple regressions?

4) Is it legitimate to exclude the natural resource industries?

5) Is it legitimate to include measures like the indices of scale and unionization?

6) What economic phenomena are generating the disturbance term in these regressions and what stochastic properties should be assumed? Regressions never fit exactly and a careful discussion of why is essential. For example, without knowing what economic phenomena the disturbance term is capturing, it is impossible to evaluate the reasonableness of orthogonality assumptions.

These questions can only be answered with reference to a clear theoretical framework.

Leamer has argued in several papers, (Leamer and Bowen (1981), Leamer (1984b) and Leamer (1987)), that cross-industry regressions generally have an unclear theoretical foundation. In deciding the kind of equation to estimate, the first important question is how to scale the dependent variable in a way that makes the cross industry comparisons sensible. The absolute level of output or trade does not seem to be a very sensible dependent variable because some commodity groups form large shares of output and consumption whereas others form small shares. If no attempt is made to control for scale, any explanatory variable that is correlated with the size of the commodity group will pick up the scale effect. To put this another way, without some way to correct for the relative sizes of different commodity groups, the estimates will be highly sensitive to the level of aggregation. The scale effect has traditionally been controlled by dividing the dependent variable by some measure of market size. The ideal candidate would seem to be total world output. What seems to lie behind this normalization is the intuitive notion that a country's share of world output can be expected to depend on the input mix of the commodity: Thus countries that are abundant in capital ''ought'' to have larger shares of capital intensive industries than of labor intensive industries. But what seems intuitively clear is not always true. To explore this formally, let us focus on the production side of the Heckscher-Ohlin model with equal numbers of factors and goods and with sufficient similarity of endowment supplies that all countries have the same factor prices and use the same input mixes.

Equation (3.1) then identifies a set of relationships between outputs, factor intensities and factor supplies. If data are collected for a single country only, then the endowment vector V is necessarily constant and (3.1) explains the level of production of each commodity as a function of the factor intensities A. (This is the type of regression discussed in the above section on the Rybczynski theorem.) This equation suggests that the ''correct'' variables to include in the equation are elements of the inverse of A, not elements of A. Usually, however, the dependent variable is not selected to be the level of output which can vary enormously if data are in monetary units and oddly if data are in other units. It is traditional to normalize by a variable that represents the ''size'' of the commodity in world markets such as the level of the world's output of the commodity. By Cramer's rule, the share of the country output of commodity one is

$$Q_1/Q_{1w} = det[V, A_2, A_3, ..., A_N]/det[V_w, A_2, A_3, ..., A_N]$$

where A_j refers to a column of the matrix A, Q_{1w} is the world output of commodity one and V_w is the world's vector of factor endowments. *Note that this formula indicates that the share of world output of commodity one does not depend on A_1, the input mix in industry one!*[9] This model thus suggests that it is entirely inappropriate to regress output shares on characteristics of industries.

Many cross-industry regression studies in the literature have not used the world shares as the dependent variable. Typically, the dependent variable is the ''trade-dependence ratio'' equal to the level of net exports as a share of domestic consumption. Exactly the same comment applies if the model (3.1) - (3.4) is used. Using Cramer's rule we can solve for the trade dependence ratio for the first commodity as:

$$T_1/C_1 = det(V - sV_w, A_2, A_3, ..., A_n)/det(sV_w, A_2, A_3, ..., A_n)$$

The same result thus applies: *the trade dependence ratio in industry one is altogether unrelated to the characteristics of that industry.* This suggests something of a puzzle, though, for some of these regressions actually fit the data reasonably well. What is going on here?

Another comment on cross-commodity regressions is offered by Leamer and Bowen (1981). It has been a tradition to regress trade on factor intensities and to assume that the signs of the

[9] Leamer (1984a)

coefficients reveal the relative abundance of factors. For example, a country that is relatively well endowed with capital is expected to have a positive coefficient on the capital variable when trade is regressed on a set of factor intensities. But as Leamer and Bowen (1981) observe, there is no assurance that this is true. The regression vector formed when the unscaled trade data T are regressed on the input intensities A is $(AA')^{-1}A'T = (AA')^{-1}(V - sV_w)$, which has the same sign as $(V - sV_w)$ only under special circumstances.

Bowen and Sviekauskaus (1992), though, argue that while this is certainly true in theory, in practice this concern is not very important. They run several cross-industry regressions and show that the signs of the estimated coefficients usually match the sign on the revealed factor abundance when data on technologies are used. They note that the regression approach works well, but that it is important to correct the trade data for trade imbalances. The general message from Bowen and Sveikauskas is that while the cross-industry approach may not be theoretically correct (as would be the case if factor complementarities were strong), in practice the problem is not severe.

Although the HOV framework seems theoretically incompatible with multiple regression, it can be used to justify the calculation of simple correlations. If trade is balanced, the theory predicts that the sign of the simple correlation between the trade vector and a set of input intensities is the same as the sign of the excess factor supply $V - sV_w$. For example, a country that is well endowed in capital will have trade positively correlated with capital intensity. By this type of reasoning, the simple correlations in Table 4 suggest that the U.S. was relatively abundant in all the skilled labor categories and relatively scarce in unskilled labor.

More than just the sign, it is natural to suspect that the simple correlation between trade and factor intensity is highest for the factor that is most ''important'', scientists and engineers in Table 5, for example. Although the absolute value of the predicted correlation is indeed high if the supply of the resource is unusual, it is also high if the input intensities are highly variable across industries.

Petri (1991) relaxes the assumption of factor price equalization and simultaneously makes a very strong set of assumptions on the demand side of the model to derive a relationship between import (or export) shares relative to total consumption and $A'w + b$ where A is the standard input-output matrix, w a vector of factor prices, and b is a vector of tariff equivalents. The demand side assumptions amount to assuming that all goods are differentiated by country of origin *and* that the choice among varieties of one product (what's a product?) does not depend on the choice among varieties of the other products. This is a strong form of separability. Petri linearly regresses import penetration and export shares for 49 manufacturing industries in Japan in 1985 on a series of proxies for comparative advantage, market structure, and protection. The extensive use of proxies makes it difficult to know just what to make of the results, but Petri does provide a theoretical justification for cross-commodity regressions by relaxing the FPE assumption and adding strong assumptions on the demand side.

3.4.3 Studies of the Heckscher-Ohlin Model Based on Cross Country Comparisons

Cross-country comparisons are another way to study the validity of the Heckscher-Ohlin Theorem. Studies of this type hold fixed the commodity and use the country as the experimental unit. Normally the tool of analysis is multiple regression, with some measure of trade performance as the dependent variable and various characteristics of countries as the explanatory variable. Chenery (1960), Chenery and Taylor (1968),Chenery and Syrquin (1975), were some of the earliest studies of this type, although these studies did not deal with details of the structure of trade but rather with more aggregate features of the economy like the ratio of gross imports to GNP. Leamer (1974) was one of the first to study commodity composition questions, contrasting the performance of three groups of variables as predictors of imports disaggregated by commodity; these groups are resistance(tariffs and distance), stage of development(GNP and population) and resource supplies (capital,labor, education and R&D). Leamer finds that the development group is generally most important in helping to predict import patterns.

The theory underlying many of these cross-section regressions is casual at best. This contrasts with Leamer (1984b) which takes equation (3.3), the H-O-V model $T = A^{-1}(V - sV_w)$, as the clearly stated foundation for running regressions of net exports on factor supplies. One function of such an estimation exercise implicitly is to infer the value of A^{-1} and to study how this changes over time. The question that is implicitly addressed is: "What resource supplies determine comparative advantage?"

Some typical results from Leamer (1984b) are reported in Table 6. These are beta-values from regressions of four commodity aggregates on 11 resource supplies. The data refer to trade and resource supplies of 60 countries in 1975.[10]

Based on these beta-values, comparative advantage in cereals is associated with abundance of highly skilled labor, land of type 3 and oil. Comparative advantage in the three manufactures is associated with supply of the moderately skilled workers and capital, and is negatively related to the supply of land.

3.4.4 Multi-cone Models

The foregoing discussion is based entirely on the one-cone model in which countries produce the same mix of products and factor price equalization holds. When data from developing countries are combined with data from developed countries, the possibility of multiple cones of diversification needs to be explicitly considered. This is not an easy task empirically because the theoretical model with multiple cones has as its basic feature something which is not present in any data set: namely the complete absence of output of some products. This theoretical feature needs to be "softened" in some way before data are examined. Leamer (1994) does this somewhat casually by including non-linearities in the Heckscher-Ohlin and Rybczynski functions. Trefler (1994) also has a multi-cone feature in his technological differences.

Incidentally, in deference to the one-cone model it has been the tradition in this literature to take the dependent variable to be net exports. Most analysts must worry that something is lost by not studying imports and exports separately. The multi-cone model is a natural theory on which to base such a study.

The multi-cone model may also serve as a casual foundation for the cross-industry regressions about which we have been so critical. As Baldwin and Hilton (1983) observe, production cost is the inner product of factor prices and input intensities.[11] In the one-cone model, both factor prices and input intensities are identical, and production costs do not vary across countries. But in the

10 A beta coefficient is equal to the estimated coefficient times the ratio of the standard error of the explanatory variable to the standard error of the dependent variable. A beta coefficient answers the question: if the explanatory variable changes by one standard error, by how many standard errors does the dependent variable change?

11 See also Petri (1991).

multi-cone model, factor price differences across countries can give one location a cost advantage over another. The cross industry regressions of trade performance on input intensities can then be interpreted as a regression of market share on cost advantage. This has a great deal of appeal, but don't forget that pooling data across different industries implicitly assumes that the same demand conditions apply in all.

3.4.5 Cross-Country Comparisons of Production Functions

We have discussed in several instances inferences drawn from trade data concerning technological differences among countries. This seems like such an important possibility that it calls for more direct international comparisons of production functions. It is interesting that there is a very old literature on the comparison of production functions that seems not to have been followed up. Minhas (1962), drawing heavily on Arrow, Chenery, and Solow (1961), makes use of the CES production function to examine both the empirical importance of factor intensity reversals and international differences in technology using factor data on only labor and capital. Minhas claims to find factor intensity reversals and also differences in technologies, though Leontief (1953) mounts a spirited counterattack.

3.4.6 Summing Up

The voluminous and complex literature on testing and/or estimating Heckscher-Ohlin models may appear to have left the framework battered and beaten, but nonetheless it remains entirely healthy. Some of the attacks are irrelevant because they used inappropriate methods. The more serious attacks using appropriate methods require us to enrich the simple one-cone model, not to discard it. ("Give it a chance." in the words of Adrian Wood. See Wood (1994a).) The model needs to include especially technological differences, home bias, and multiple cones of diversification. After allowing for these factors, there appears to be a substantial effect of relative factor abundance on the commodity composition of trade. Of course, not all of international trade can be explained without reference to economies of scale and product differentiation, subjects to which we now turn.

4. Models with Monopolistic Competition

The intellectual life cycle of a trade theory typically begins with an elegant theory and only in adulthood (or senility) is the theory examined empirically. The intellectual life of the theory of international trade with monopolistic competition is an exception to this pattern. Empirical work came *first*. Grubel and Lloyd (1975) noted that when inspecting trade flows, a significant amount of international trade was within industry classifications. Their work did not include a formal theory. In terms of evidence, though, their data appendix gives measures of intra-industry trade for a broad array of two-digit industries.

The index of intra-industry trade they used, since coined the Grubel-Lloyd index is given by:

$$IIT_{ijk} = \frac{2\, min\, (X_{ijk}, X_{ikj})}{(X_{ijk} + X_{ikj})}.$$

where i indexes the industry, and j and k index countries. Exports of i from j to k are denoted by X_{ijk}. This index has the appealing property that it varies from zero (no intra-industry trade) to one (all intra-industry trade.) Some of the first empirical work dealt with whether the existence of intra-industry trade, as evidenced by the Grubel-Lloyd index, is really inconsistent with more traditional endowments-based motivations for trade. Grubel and Lloyd themselves noted that goods that are homogeneous with respect to production and consumption may still be differentiated by either location or by time. The former gives rise to border trade while the latter gives rise to seasonal trade. Trade in these goods will be measured as intra-industry trade even though such trade is not really inconsistent with an endowments-based story.

Finger (1975) has argued that intra-industry trade is a figment of the data classification. At the highest level of aggregation (one commodity), this is tautologically true. Regardless, the phenomenon (real or data-induced) stimulated much empirical work. This work did not take the theory "seriously" since there was, in the late 1970's, no formal theory. Instead, this work searches for correlates and partial correlates of an index of intra-industry trade.

A representative empirical study of this sort is Loertscher and Wolter (1980). They note that the following hypotheses *seem warranted* (our italics.)

Intra-industry trade between countries should be intense if:

1) the average of their level of development is high;

2) the difference in their levels of development is relatively small;

3) the average of their GDP's is large;

4) the difference in their GDP's is small;

5) barriers to trade are low.

Intra-industry trade in an industry should be intense if:

6) the potential for product differentiation is high and market entry in narrow product lines is impeded by significant barriers;

7) transactions costs are low;

8) the definition of an industry is comprehensive.

Loertscher and Wolter then construct proxies for each of these phenomena. For example, per capita GDP proxies for level of development, a distance variable and customs union dummy variable proxy for barriers to trade, and the number of 4-digit classifications within a 3-digit classification proxies for how comprehensive an industry definition is. Using these proxies, Loertscher and Wolter run ordinary least squares multiple regressions with these regressors using a cross-section of 3-digit SITC data from OECD countries. The independent variable is one of two arbitrary but reasonable indexes of intra-industry trade. (They do not use the Grubel-Lloyd index.) Their results are reproduced in Table 7.

Some of the signs of the coefficients make intuitive sense were they simple correlation coefficients. For example, the regression indicates that countries that are closer to their trading partners and that have similar incomes experience more intra-industry trade. Other coefficients, such as that on scale economies, are counter- intuitive.

Loertscher and Wolter note that "The equation presented [in the above table] is the best fit estimate of both linear and logarithmic formulations of the exogenous variables, chosen from those equations which yielded a maximum number of significant coefficients." This kind of specification searching is characteristic of the empirical literature on monopolistic competition. See, for example, Caves and Jones (1981), and Balassa (1986a). There are several important problems with this approach.

First, authors in this literature frequently tell a fairly convincing story about why, for example, scale economies might be positively correlated with intra-industry trade. They also can tell a similarly convincing story about why a customs union dummy variable might be positively correlated with intra-industry trade and a market size differential negatively correlated. These stories argue for empirical work that computes simple correlations. What none of the authors do, though, is tell a convincing story about why, for example, in the presence of a customs union and scale economies, increasing the size differential between trading partners will also increase intra-industry trade. Yet it is these partial correlations, conditional on the other included regressors, that these studies always estimate.

Second, the "kitchen-sink" attitude toward the choice of variables makes the list of possibilities very long and the extensive data-mining that is used to prune this long list makes the final estimates highly suspect. Even after all the mining, the R^2 typically is very small. With an R^2 as small as the one reported in Table 7, the *signs* of the (precisely estimated) coefficients are not very robust to measurement error adjustments. See Klepper and Leamer (1984) for relevant bounds tests.

Third, it is often difficult to find an observable that closely measures the hypothetical construct stipulated by the theory. For example, Loertscher and Wolter measured ''the potential for large scale production'' by value added per establishment. But it is not obvious what this has to do with the fixed costs and differentiated products that are the bases for models of intra-industry trade.

Fourth, in many of these studies, the variation in the data is cross-industry, yet we believe that studies that combine data from many industries are suspect, since the theoretical underpinnings of these studies are often quite weak. Economists would (or at least, should) distrust estimates of a price elasticity of demand based on observations of price and quantity collected from many industries. Some of this distrust ought to carry over to the cross-industry studies patterns of trade.

Clearly, here is a setting that could stand a good dose of economic theory. Krugman's theoretical paper on monopolistic competition and international trade (Krugman (1979) and the ensuing work by Helpman and Krugman (1985), represent a step in the right direction, but these simple models do not really help much in studying the impact of scale economies and product differentiation on trade. Most empirical work continued to compute correlates of indexes of intra-industry trade with each trying to medal a competition for the highest R^2. Balassa (1986b) took the gold medal with an R^2 = .999 using cross-industry U.S. data and 15 regressors. We note that one regressor which always shows up very significantly in these studies is distance. (We expand on this in section 6 below.)

One of the first studies that attempted to make a formal link between theory and data was Helpman (1987). In this paper, Helpman examines three hypotheses that emerge from theoretical models of monopolistic competition using OECD data spanning 1956 to 1981. Helpman's first empirical test concerns the volume of trade in a model in which all trade is, by assumption, intra-industry trade. Neglecting a correction for trade imbalances (which does not change any of the empirical results), Helpman defines an index of size similarity for a group (I) of trading partners. This index is given by:

$$SIMILARITY_I = 1 - \sum_{j \in I} (s_j)^2$$

where s_j is country j's share of group I's GDP. If all GDP originates from a single country, this index takes on the value 0. It is maximized when all countries are equal in size. Total intra-group trade (which by assumption is also intra-industry trade) is defined as

$$V_I = \sum_{i \neq j} X_{ij}$$

where X_{ij} is the value of exports from i to j. Helpman's theoretical model implies that trade increases with $SIMILARITY$:

$$\frac{V_I}{GNP_I} = \frac{GNP_I}{GNP_{world}} * SIMILIARTY.$$

Helpman computes the right-hand and left-hand side of this equation for the OECD for each of the 26 years in his sample. He graphs these and finds that the theory is supported in that both the volume of trade and the measure of size similarity increased over time together.

What is being summarized in this complicated way are two simple facts. First, trade has recently increased more rapidly than GDP for the OECD countries. Second, the U.S. share of OECD GDP has fallen substantially, and thus the U.S. size is more similar to other OECD countries. While these facts are compatible with a model of monopolistic competition, they are also compatible with many other models, specifically any model with an ''Armington'' demand side in which goods are differentiated by country of origin. But even a standard HO model with homogeneous commodities produces the result that the trade volume is low if most of the world's GDP originates in a single country.

Helpman's first "test" is based on a structural equation from a model in which all trade is intra-industry. His other "tests" are based on a model in which some trade is intra-industry and some trade is endowments-based. The hypotheses that he studies concern the share of total trade that is intra-industry trade. While he does not derive a structural equation from the theory, he reports that his theory ''suggests'' (the same word as Loertscher and Wolter!!) that: ''The share of intra-industry trade in bilateral trade flows should be larger for countries with similar incomes per capita.'' Helpman calculates bilateral intra-industry trade as the Grubel-Lloyd index given above. For each year from 1970-1981, this measure of intra-industry trade is regressed on:

$$X_1 = ln \mid (GDP_i/POP_i) - (GDP_j/POP_j) \mid,$$

$$X_2 = min(ln(GDP_i, ln(GDP_j)),$$

$$X_3 = max(ln(GDP_i, ln(GDP_j)),$$

The inclusion of X_1 as a regressor is robust to several theoretical specifications, while the min and max GDP variables are less so. The intuition behind including the difference in per-capita GDP's is fairly straightforward. This variable is proxying for differences in relative factor endowments and the proxy is exact when there are only two factors. If two countries have identical relative endowments, there is no role for endowments based (Heckscher-Ohlin) trade, and all trade is intra-industry trade. Hence theory suggests that the coefficient on X_1 is negative. Helpman runs this regression separately for each of the 12 years of his data and finds that the coefficient on X_1 is negative although the precision of the estimate declines steadily over the sample years. By the end of the sample, the R^2 has fallen from 0.266 to 0.039. The coefficient on X_2 is positive and usually precisely estimated while that on X_3 is negative and less precisely estimated. The signs are those suggested by the theories of monopolistic competition that Helpman considers.

A second set of regressions reported by Helpman separates GDP size from GDP similarity and confirms that both seem to contribute positively to intra-industry trade.

Helpman, like Loertscher and Wolter, concludes that the theory finds some support in the data. But there is clearly a lot that needs to be done. We need to know how much of the results are due to tastes and how much to monopolistic competition. It would also be interesting to know which industries are "Heckscher- Ohlin" and which are "Chamberlainian." How much of trade is due to economies of scale and how much to factor supply differences? What does this imply about policy?

Hummels and Levinsohn (1994. 1993) follow up on Helpman's paper. They use country-pairs. instead of the entire OECD, as their unit of observation, and instead of estimating each year as a separate regression, they employ standard panel data econometric techniques (fixed and random effects for country pairs.) They report two main results.

First, the model in which all trade is. by assumption. intra-industry trade and trade volume within a group depends on the size similarity of the countries comprising the group finds support for both an OECD data set (like in Helpman's) and for a data set in which a model of monopolistic competition is *ex ante* inappropriate. The latter data set comprises a random selection of developed and developing countries distributed across the globe. Hummels and Levinsohn conclude that perhaps something other than monopolistic competition is generating the empirical success of the estimating equation.

Second, the estimating equation in which the share of trade that is intra-industry trade is explained by the differences in log per capita GDP is less robust to standard panel data estimation. Hummels and Levinsohn use OECD data from 1962 to 1983. Organizing the data so that each country pair in a given year constitutes an observation, they first (successfully) replicate Helpman's tests. They then demonstrate that when fixed (or random) effects estimators are used, thereby accounting for non-independence in the residual within country pairs but over time, and when one instruments for the endogeneity of GDP, the results disappear and the theory finds little support in the data. They conclude by noting that most of the variation in intra-industry trade is explained by factors idiosyncratic to country pairs. Residual analysis also leads them to suspect that distance and multinational corporations may be empirically important variables that do not enter the theory.

Harrigan (1992) also estimates an equation purporting to explain bilateral trade volumes in a model of monopolistic competition. He conducts a residual analysis to examine which countries are outliers. He finds that, within the OECD, the European Union countries engage in more trade than is predicted by the model, while the U.S. and Japan engage in much less than is predicted by the model.

In Helpman, Hummels and Levinsohn, and Harrigan, it is unclear why countries like the U.S. and Japan are often outliers, with much less intra-industry trade than the model predicts, while bordering EC countries often have the most intra-industry trade. Their methods do not separately identify the often empirically collinear effects of customs unions and distance. For example, do Belgium and the Netherlands have a lot of intra-industry trade because they are close to one another or because of special trade policies?

These recent studies demonstrate a tension in this literature. The authors refrain from tossing in whatever regressors seem like they *ought* to matter. Yet, when one examines why the estimating equation does not fit the data very well, one is tempted to move in that direction. These studies are helpful, though, for they are beginning to demonstrate where the theory, taken seriously, needs amendments. With modified theory, new empirical work will surely follow.

Models with monopolistic competition motivating intra-industry trade *and* factor endowments motivating traditional trade have also been most recently examined. One study (Harrigan (1993)) focuses on what such a model implies about trade in intermediate goods. Another (Brainard (1993a, 1993b)) focuses on what the model implies about multinational corporations. Each are briefly discussed in turn.

Harrigan begins by noting that an implication of the Helpman and Krugman (1985) model, in which some trade is intra- industry and the rest is endowments-based, is that gross import volumes do not depend on the importing country's relative factor endowments, although net industry trade balances are influenced by factor endowments. This result, though, is only correct when the differentiated products are for final consumption by variety-loving consumers. If the differentiated products are used as intermediate inputs by final goods producers, the volume of gross imports will depend on the industrial structure of the importing country. Taking his theory carefully into account, Harrigan finds that his model-- in which the bilateral volume of trade in manufactures depends on the structure of the importing country's industrial sector-- is rejected by the data. Instead, simpler models of monopolistic competition in final goods such as the above mentioned papers by Helpman, Levinsohn and Hummels, and Harrigan better explain the data.

Brainard notes that different theories of international trade have different implications for how multinational corporations behave. She writes that ''the same tests on intra-industry trade ratios and total volumes that were used to demonstrate that a substantial part of trade is explained by factor and income similarities rather than differences''(Brainard (1993a), p. 1) can be applied to tests of multinational trade. In particular, she asks whether a factor proportions view of the world can explain the location patterns of U.S. multinational firms. In the factor proportions model, multinational firms arise because factor price equalization does not obtain. The factor price differences arise due to large variations in relative factor endowments. Firms move to take advantage of the lower factor prices abroad and then re-export to their home country. An alternative to the factor-proportions model posits locational advantages in terms of proximity to customers. This advantage to multi-nationalization is balanced against the benefits of scale economies that are realized when all production is in the home country. This model, in contrast to the factor proportions model, implies that the firms will not export back to their home countries. Using industry-level data on inter-affiliate sales by U.S. multinationals. Brainard investigates these hypotheses. She finds that (p. 25) ''Overall, the evidence suggests that only a small part of multinational activity into and out of the U.S. in the late 1980's can be explained by factor proportions differences.'' Rather, the same variables measuring similarity among trading partners (similarity in per capita GDP as in Helpman (1987), for example) that have been used in empirical studies of intra-industry trade also explain the volume of inter-affiliate trade reasonably well. She also finds that trade flows and multinational sales differ in their response to trade barriers and transport costs.

5. Demand-Side Explanations for International Trade

International trade is determined by both international patterns of production and consumption. Most of the theoretical literature in international economics concentrates on the production side and often uses assumptions that neutralize demand as a determinant of the composition of trade. From a theoretical vantage point, the studies of the effect of demand on trade are somewhat self-limiting. After all, one could impose assumptions that neutralized differences in technologies or endowments and tautologically explain all trade flows as reflecting differences in tastes. Still, while differences in tastes might not be all that theoretically exciting, they might nonetheless be empirically important.

Linder (1961) was one of the first to argue that demand played a role in determining trade patterns. While Linder did not have a formal model, he had a compelling story. Linder argued that countries with similar demand structures would develop similar sets of goods, first for home consumption and later for export. The resulting trade would look like intra-industry trade. If per-capita income, though, is a good gauge for demand, countries with similar and sufficiently high incomes will engage in a lot of (intra-industry) trade. This is usually interpreted to mean that the intensity of bilateral trade decreases with differences in per capita income. The Heckscher-Ohlin model, on the other hand, ''suggests'' the reverse association because countries with substantially different per capita incomes are ''likely'' to have different resource endowments, offer different baskets of goods for trade and therefore become trading partners.

Most of the theoretical work in traditional trade theory deals with the commodity composition of trade, not the partner composition. The Linder hypothesis has traditionally been interpreted in terms of its implications for partner composition by including a measure of similarity of per capita GNP's in ''gravity equations'' that explain bilateral trade. For an example of work in this vein that builds a rigorous economic model, as opposed to just a compelling story, see Bergstrand (1985).

An interesting example of a gravity model is estimated by Hoftyzer (1984) who attempts to explain the 1970 bilateral trade of each of eleven importers using data for fifty eight exporters. The Linder Hypothesis is interpreted to mean that the dissimilarity of countries as measured by the difference in per capita incomes will lower the intensity of trade. In other words, the coefficient on differences in per capita income between trading partners should be negative. Hoftyzer finds otherwise, in the sense that the estimated coefficient is positive for most countries. This contrasts with some more supportive results by other authors, which Hoftyzer argues are due to their failure to control for border effects and membership in free trade associations and their failure to consider other functional forms, as he does by means of a Box-Cox analysis.

Even though the theoretical foundation is murky, the findings of Hoftyzer seem to us to be unsettling to the Linder viewpoint. According to Hoftyzer, trade may seem intense between similar countries, but that can be explained by the fact that they are neighbors and/or members of free trade associations. Moreover whatever relationship does exist, it is probably not log-linear. The idea that distance between trading partners may matter for bilateral trading patterns is taken up in the next section.

A different approach to investigating the effects of demand on trade is adopted by Hunter and Markusen (1988). Hunter and Markusen note that if one allows completely general preferences, then one can always estimate taste parameters consistent with any pattern of trade. Therefore, the research is forced to impose some structure on the problem. Hunter and Markusen adopt the Linear Expenditure System (LES) while maintaining the assumption of identical preferences across countries. They relax, though, the assumption of homotheticity. In this way, per capita income plays a role in determining the pattern of trade. Hunter and Markusen estimate the LES using data on eleven types of expenditures and deflators culled from the Penn World Tables. They then pose the following thought experiment. Suppose all countries had identical relative endowments and technologies, hence removing the basis for inter-industry trade. Based solely on differences in per-capita income, how much trade would take place? Their answer to this counter-factual is about 14 percent of observed trade.

6. International Trade and Distance between Partners

What about proximity as a source of comparative advantage? At one level of consciousness, economists have long been aware of the impact of distance on the patterns of international commerce. Some of the earliest empirical studies in international trade were Beckerman (1956) with his studies of intra-European trade flows, and Poyhonen (1963), Tinbergen (1962) and Linnemann (1966) who estimated ''gravity'' models.

A gravity model is a typically log-linear relationship expressing bilateral trade between a pair of countries as a function of the two countries' income levels, populations, and distance. Typically included also are an adjacency dummy, a common language dummy, and dummies for commercial preferences such as the EEC and the British Commonwealth. Tariffs and transportation costs are sometimes explicitly included, but data on these variables are sometimes difficult to obtain. These gravity models are usually estimated for total trade, but Frankel (1991) does some disaggregation and Leamer (1993a) studies 3-digit ISIC data from OECD countries. These and many subsequent studies have found a distance elasticity of about -0.6.

These estimates of gravity models have been both singularly successful and singularly unsuccessful. They have produced some of the clearest and most robust empirical findings in economics. But, paradoxically, they have had virtually no affect on the subject of international economics.[12] Textbooks continue to be written and courses designed without any explicit reference

[12] A possible exception is the rebirth of interest in economic geography which is discussed briefly below.

to distance, but with the very strange implicit assumption that countries are both infinitely far apart and infinitely close, the former referring to factors and the latter to commodities.

Why don't trade economists "admit" the effect of distance into their thinking? How can this obvious conflict between fact and theory continue? These questions have several possible answers. One is that human beings are not disposed toward processing numbers, and empirical results will remain unpersuasive if not accompanied by a graph. As a step toward remedying this potential problem, we include Figure 4 from Leamer (1993a), which is a scatter diagram illustrating the relationship between distance and West Germany's volume of bilateral trade in 1985.

On the vertical axis is total trade (exports plus imports) scaled by partner GDP. On the horizontal is the distance to the partner's geographic center. Both scales are logarithmic. The figure shows, clear as day, that distance matters, and it matters a lot!

Another possible explanation for their limited influence is that gravity models and international economics have separate intellectual domains. Gravity models are usually concerned with the total trade between pairs of countries, whereas the subject of international economics is concerned with the trade of a country vis-a-vis the world, and has little to say about the choice of its trading partners. While there is some truth to this, there is more intellectual overlap than is apparent. Geographic size and geographic isolation can affect both the total trade of a country and also the composition of that trade. Countries like the United States that form large geographic areas have much of their economic mass far from their borders, and they are accordingly much less dependent on trade than smaller countries. Small Asian countries that are far from the economic mass in either Europe or North America specialize in products that travel well over long distances. In contrast, the countries of Europe have a mutual comparative advantage over Asia in the European marketplace in those commodities that do not travel well. To give a hint what these commodities are, Table 8 contains the percent of trade in 2-digit ISIC categories that occurs between adjacent countries. At the top of the list are wood and paper products which do not travel well. Near the bottom are wearing apparel and footwear, which do travel relatively well.

A third possible explanation for the lack of influence is the very weak link between theory and the empirical work. The gravity models are strictly descriptive. They lack a theoretical underpinning so that once the facts are out, it is not clear what to make of them.[13] In addition, they do not link clearly with any issues: For example, the basic proposition that free trade is beneficial doesn't seem obviously at risk if distance is added to the model, so why bother? But the clarity of the empirical findings and the absence of distance in the standard theory creates a degree of professional tension that needs to be remedied by a much closer association of the descriptive gravity models with the theory and with the issues of international economics. Furthermore, once we admit distance between countries into our theories, it begs the question: what about the role of distance within them?

The impact of the EEC on trade was one source of issues on which gravity models were first focussed (e.g. Aitken (1973)). More recently, interest in regional trading blocs is generating a new flurry of gravity models offered by Frankel and others (e.g. Frankel and Wei (1993), Frankel, Stein, and Wei (1994), Frankel and Wei (1994)), Leamer (1993), and Losada (1993). At the theory level, Krugman (1991) has made an effort to bring to the attention of international economists the substantial body of work by economic geographers. This work, though, typically focuses on issues such as path dependence and agglomeration economies-- issues that may be more important to where a firm locates than to which countries it trades with. Krugman's work on geography is somewhat more subtle than the ''look at a map'' notion of distance that we are thinking about. Rauch (1990) has included geographic area as a determinant of trade dependence in a theory supported by evidence. Trefler (1994), in a very promising development, has successfully allowed for "home bias" in a Heckscher-Ohlin based study of net trade in factor services, a'la Bowen et al. (1987). Although Trefler doesn't do so, it seems appropriate to link home bias with distance. Hummels and Levinsohn (1993) also experiment with distance as an explanation for why a Helpman-Krugman model of intra-industry trade and endowments-based trade fits the data so poorly. They too find that distance matters very much.

Finally, it seem appropriate to mention that the effect of distance on trade patterns is not diminishing over time. Contrary to popular impression, the world is not getting dramatically

[13] An attempt to give a theoretical foundation by Anderson(1979) is formally fruitful but seems too complex to be part of our everyday toolkit.

smaller. You can see this a bit in the figures in the last column of Table 8, which reports the 1985 adjacency shares divided by the 1970 adjacency shares. The share of trade between adjacent countries did decline overall from 30.6% to 27.6%, but there are plenty of commodities for which the adjacency share increased. More to the point, Leamer's (1993) estimated distance elasticities in 1985 are not dramatically smaller than the 1970 elasticity. How can this be so? We know that there has been a large increase in trade across the Pacific and the Atlantic? Why isn't this picked up by a declining effect of distance in the gravity models? The answer is that the gravity models account for economic size as well as for distance. This model predicts that the smallest amount of world trade occurs when most of the world's GDP originates in one country (e.g. the U.S.). As the U.S. share of world GDP has declined, this implies an increase in the volume of trade relative to world GDP, even though the effect of distance remains exactly the same. Indeed the increased trade across the oceans is almost fully explainable by the increase in the economic sizes of Europe and Asia. Thus, dispersion of economic mass is the answer, not a shrinking globe.[14]

In this appendix, we discuss some important sources for the sort of data international microeconomists might find helpful. While a complete compendium of actual and potential data sources is beyond the scope of this review, hopefully researchers will find even a brief review somewhat useful.

The most used data source on international trade flows is probably the United Nations Trade Data Tapes. This data base provides bilateral trade flows at the 4 and/or 5 digit SITC level. There are a few minor problems with this data and one major problem. The minor problems include the use of SITC industry codes, while much other international data uses the ISIC industry codes, and the fact that imports reported by one country for a particular good frequently do not match the exports reported by the partner country for the same good. (There are concordances to deal with the former problem.) The more major problem is that the United Nations makes these data prohibitively expensive for most academic users. While prices vary depending on the restrictions

[14] But see D.Boisso and Ferrantino (1993) for a contrary opinion that reports very large and declining distance elasticities.

attached to the use of the data and the amount of data ordered, one can easily spend over $100,000 on this data! A potentially very helpful solution to this problem is being provided by Statistics Canada. This agency has recompiled the U.N. trade data tapes, reconciled the import versus export inconsistencies, and aggregated commodities into about 600 groups (by SITC code). The entire world bilateral trade flows for 1980 to 1992 are available on CD-ROM from Statistics Canada for prices ranging from about $1750 to under $8000, with the actual price depending on how many users have access to the data (LAN connections) and whether one is an academic user (this carries a 50 percent discount.) (These prices are as of 1994 and are sure to change, but the general point is that the U.N. trade data are becoming much more available at a fraction of the U.N.'s price.) For more information, fax Statistics Canada at (613) 951-0117.

The Statistical Yearbook of the United Nations is available on CD-ROM. This data base is a comprehensive description of the world economy. The U.N. Publications telephone number in the U.S. is (800) 253-9646.

Highly detailed information regarding the current structure of U.S. trade, by commodity and by partner, as well as a host of other information, is distributed on CD-ROM by the U.S. Department of Commerce for an extraordinarily nominal fee. For more information on this National Trade Data Base call the help line at (202) 377-1986.

The OECD STAN DATABASE has production, value added, gross fixed capital formation, laborers engaged, labor compensation and exports and imports for 49 two-digit ISIC sectors from 1970-1991 available on diskette for $290. Information on ordering this data set is available by calling (33-1) 49 10 42 65 in Paris.

Data on endowments are available from several sources. Labor data is available from either the International Labor Office (ILO) publication *Yearbook of Labor Statistics* or from the World Bank's World Tables. (The latter are available on diskette, tel: (202) 473-1155.) Land endowments are available from the Food and Agricultural Organization (FAO) publication *Production Yearbook*. Capital stock data are not as readily obtained, but one series used by many researchers is that contained in the Penn World Tables. This data base is available free over the internet. (Details on how to explore the internet for trade data are provided below.)

Input-output tables for the United States are made available by the Commerce Department and are found in the *Survey of Current Business*. they are also available on diskette.

Data on trade and labor by industry for the United States are also found in the National Bureau of Economic Research (NBER) Trade and Immigration data set. This data set contains trade, employment and output data for 450 U.S. manufacturing industries by 4-digit SIC code from 1958-86. Variables include employment, unionization, import, exports, firm size, industry concentration as well as many other related data. This data set is free and is available on the internet. Most economics gophers can point one to this data. (A specific address is given below.)

Data on tariffs and non-tariff barriers are compiled by the GATT and UNCTAD. UNCTAD produces the TNT data base. This data base provides nominal tariff rates by harmonized tariff code as well as non-tariff measures. The non-tariff measure available is a weighted coverage ratio, where the weights used are trade values. This data is available from UNCTAD in Geneva for a few thousand dollars.

The U.S. Bureau of Labor Statistics maintains a fairly comprehensive data base on import and export price indexes for U.S. industries by SIC code. These data are free in hard copy or available on diskette for a nominal fee. The data are used in many of the studies investigating the effects of import competition on domestic wages and employment.

One very rich data set that has not been exploited much (if at all) by trade economists is the U.S. Census' Annual Survey of Manufacturers. This annual data set comprises detailed plant-level information on tens of thousands of U.S. manufacturing plants. Recent empirical work in Industrial Organization and in Labor economics has made fruitful use of these data, and international economists would probably also find them very useful. The data, though, are not especially easy to use, since one has to obtain approval from the Census bureau and all work must be conducted at their facility in Suitland, Maryland (although a new branch will soon open in Boston).

There are many other data sources that the empirical researcher in international trade may find useful. One way to search these resources is via one of the economics gophers on the internet. There are several, but a good starting point is Hal Varian's gopher. The address is: http://gopher.econ.lsa.umich.edu.

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TABLE 1

Positions Taken by Capital and Labor:

Twenty-two Industries in 1973

	Position of Labor	
Position of Capital	Protectionist	Free Trade
Protectionist	14	1
Free Trade	1	5

Note: Source: Magee(1980).

TABLE 2

Ratio of Adjusted Net Trade in a Factor to its National Endowment (times 100)

Source: Bowen, Leamer, and Sveikauskus (1987)

	U.S.	U.K.	Japan
Capital	0.08	-12.86	-5.47
Labor	-0.25	0.63	0.10
Prof/Tech	0.23	1.77	0.44
Manager	-0.11	2.04	0.48
Clerical	-0.19	1.37	0.33
Sales	-1.10	1.30	-0.05
Service	-0.68	1.32	-0.03
Agriculture	1.54	-18.57	-1.54
Production	-0.34	1.11	1.18
Land			
Arable	19.45	-313.42	-341.42
Forest	-23.82	-2573.99	-268.58
Pasture	-1.63	-91.89	-1998.58

TABLE 3
Captial per Person
Source: Hufbauer (1970)

	Abundance	Exports	Imports
Canada	8,850	17,529	11,051
United States	7,950	11,441	13,139
Norway	6,100	16,693	10,476
Sweden	5,400	12,873	11,373
Netherlands	4,750	11,768	11,706
Korea	850	8,004	14,900
India	500	7,339	12,019
Pakistan	500	5,725	12,371

TABLE 4

Simple Correlations of Labor Share and Export Performance

Source: Keesing (1966)

Skill Groups	46 Industries	35 Industries
Scientists and Engineers	.49	.72
Technicians and Draftsmen	.37	.55
Other Professionals	.41	.58
Managers	.16	.06
Machinists	.22	.37
Other Skilled Manual Workers	.11	.21
Clerical and Sales	.35	.44
Unskilled and Semi-skilled	-.45	-.64

Note: the column with 35 industries excludes natural resources industries.

TABLE 5

A Sample Baldwin Regression

Dependent Variable is (Adjusted) Net Exports by the U.S.

Source: Baldwin (1971)

Independent Variable	Parameter Estimate	t-statistic
K/L	-1.37	-4.35
Percent labor in:		
Eng. and Science	7011	2.13
Other Professional	-1473	-0.69
Clerical and Sales	71	0.06
Craftsmen/Foremen	1578	1.96
Operatives	-248	-0.79
Non-farm labor	-761	-0.80
Farm labor	845	3.81
Scale Index	-421	-1.25
Unionization Index	343	1.11

Note: R^2 for this regression is 0.44

TABLE 6
Beta Values of Net Export Regressions
Source: Leamer (1984)

	Cereals	Labor Intensive Manufactures	Capital Intensive Manufactures	Machinery
CAPITAL	-.17	.08	.78	.49
LABOR1	.74	-1.13	-1.8	-.39
LABOR2	-.55	.93	.85	.18
LABOR3	-.15	.08	.37	.02
LAND1	.09	-.04	-.03	-.01
LAND2	.03	.02	-.01	.00
LAND3	.26	-.04	-.15	-.06
LAND4	.05	-.15	-.10	-.11
COAL	.03	-.14	-.09	-.02
MINERALS	.00	-.03	-.03	-.01
OIL	.72	-.24	-.60	-.21

Note: LABOR1 is professional/technical; LABOR2 is literate but non-professional; LABOR3 is illiterate. For the LAND definitions, see Leamer(1984).

TABLE 7

Country- and Industry-Specific Determinants of Intra-Industry Trade

OECD Countries, Cross-Section 1972/73 Averages

Source: Loertscher and Wolter (1980)

	Sign of Estimate	t^2 value
Country-Specific Variables		
Development Stage Differential	(-)	47.95
Average Development Stage	(+)	1.68
Market Size Differential	(-)	82.71
Average Market Size	(+)	108.71
Distance	(-)	44.52
Customs Union dummy	(+)	64.89
Language Group dummy	(+)	6.43
Border Trade dummy	(+)	20.41
Cultural Group dummy	(-)	0.01
Industry Specific Variables		
Product Differentiation	(+)	0.45
Scale Economies	(-)	91.23
Transactions costs	(-)	3.71
Level of Aggregation	(+)	3.05
Product Group	(+)	5.56

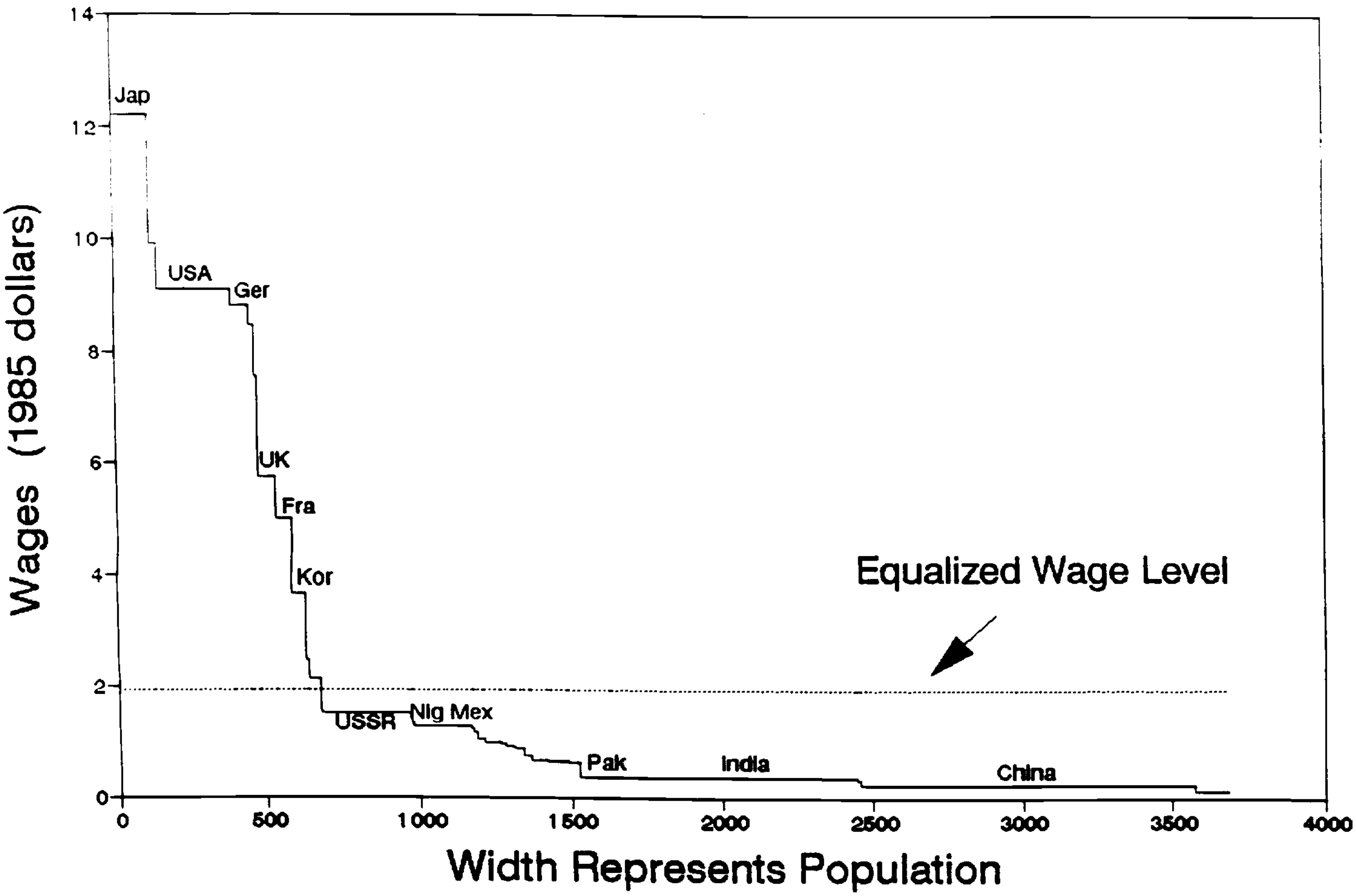
Adjusted R^2 = 0.072, and 6975 degrees of freedom.

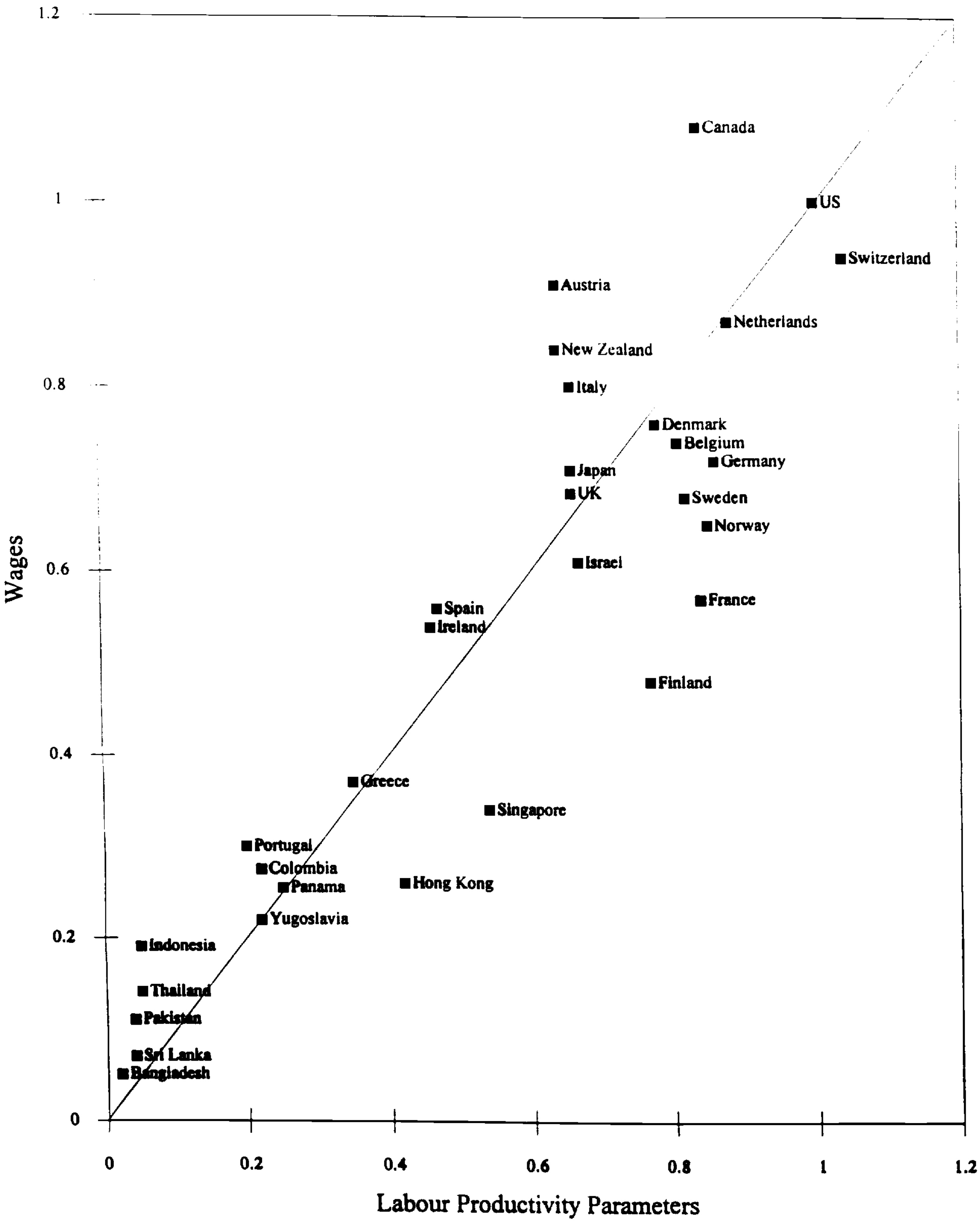
TABLE 8
Percent of Trade between Adjacent Countries
OECD Countries

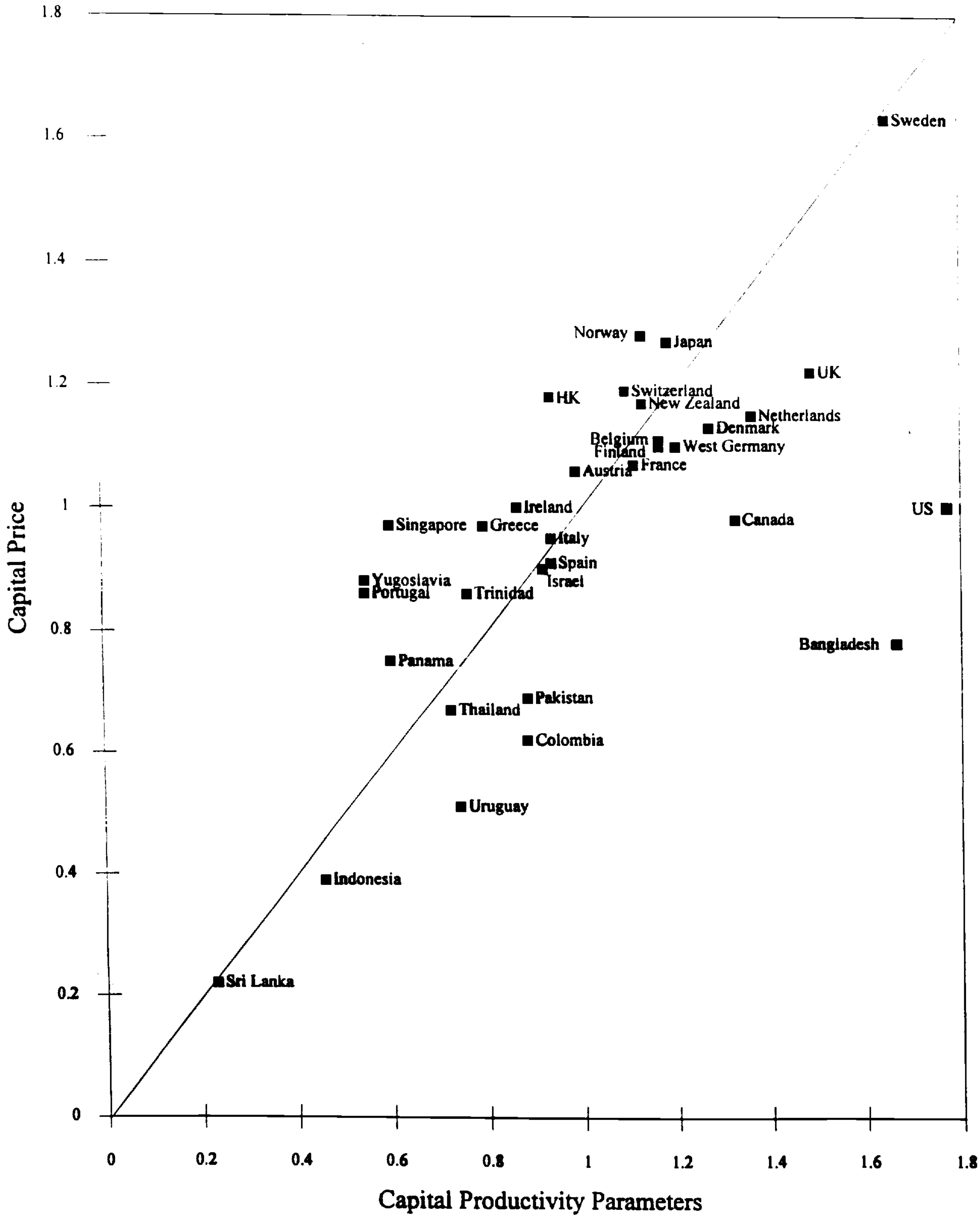
	1970	1985	Ratio
TOTAL	30.6	27.6	0.90
Wood	32.7	42.4	1.30
Printing and Publishing	40.4	41.0	1.02
Paper and Paper Products	35.9	37.7	1.05
Furniture	50.9	37.3	0.73
Transport Equipment	41.1	36.8	0.90
Misc. Petroleum Products	45.8	35.7	0.78
Glass and Glass Products	37.1	34.4	0.93
Other Non-Metallic Minerals	39.5	33.9	0.86
Metal Scrap	31.8	33.2	1.04
Other Food	31.7	32.5	1.03
Fabricated Metal Products	34.6	32.3	0.94
Rubber Products	34.1	31.9	0.94
Plastic Products	32.4	30.1	0.93
Non-Ferrous Metal Basic Ind.	26.7	28.9	1.09
Industrial Chemicals	27.9	27.8	1.00
Iron and Steel Basic Ind.	33.2	26.1	0.79
Textiles	30.3	25.3	0.84
Food Manufacturing	19.6	23.5	1.20
Beverage	26.9	23.2	0.86
Other Chemicals	24.7	23.1	0.93
Petroleum Refineries	18.2	22.9	1.26
Machinery except electric	27.7	21.8	0.79
Tobacco	22.2	20.0	0.90
Pottery, China, and Earthware	21.9	19.0	0.86
Elec. Machinery	25.2	18.9	0.75
Wearing Apparel	28.6	18.8	0.66
Leather	26.5	16.9	0.64
Footwear	17.7	16.4	0.93
Prof., Scientific, and Measuring	23.4	16.4	0.70
Other Manufacturing Industries	14.8	12.4	0.84

Note: Includes only trade flows with at least one OECD partner.

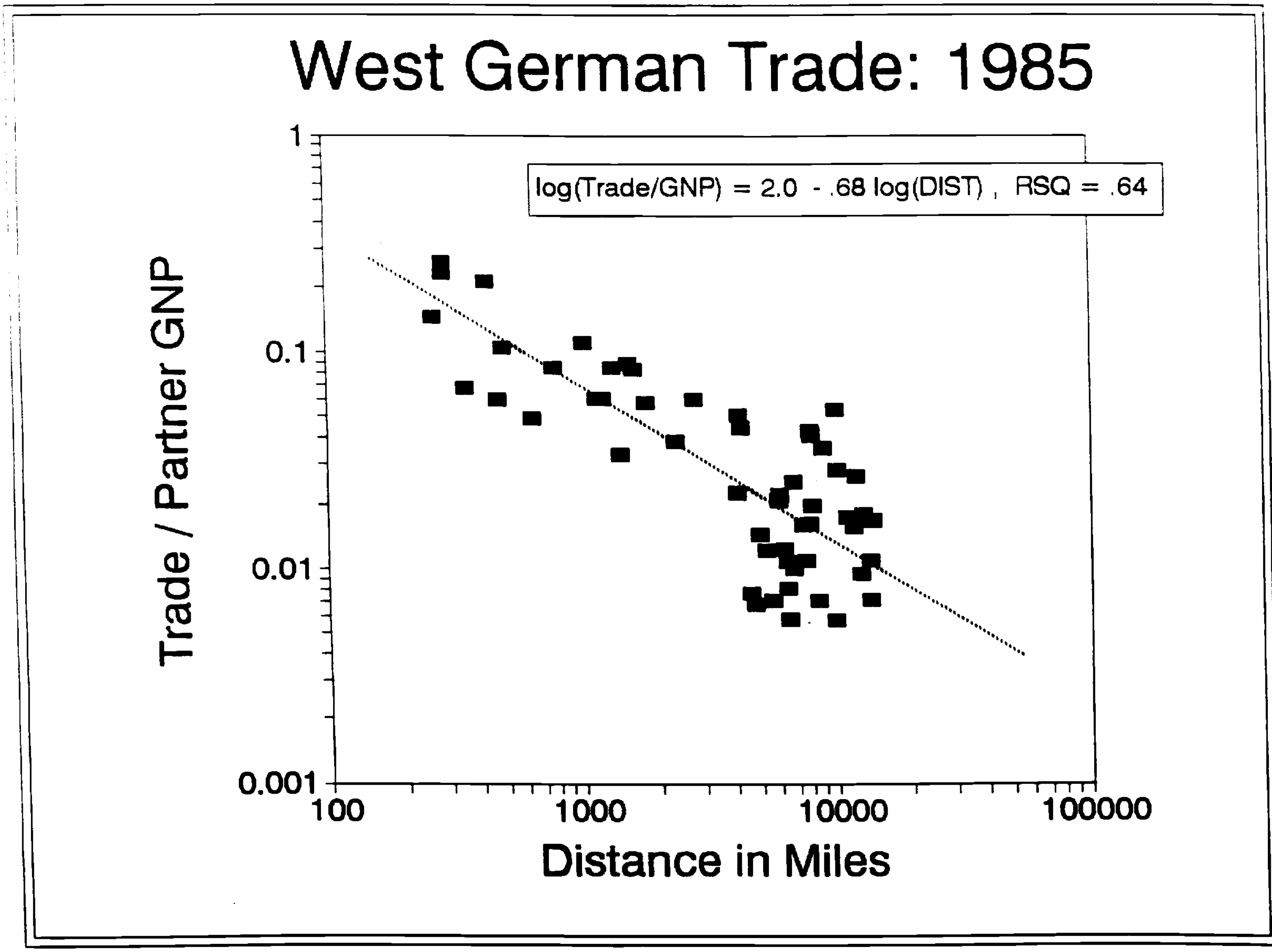
Industrial Wages and Population, 1989




Wages
Labour Productivity Parameters
0
0.2
0.4
0.6
0.8
1
1.2
Canada
US
Switzerland
Austria
Netherlands
New Zealand
Italy
Denmark
Belgium
Germany
Japan
UK
Sweden
Norway
Israel
France
Spain
Ireland
Finland
Greece
Singapore
Portugal
Colombia
Panama
Hong Kong
Yugoslavia
Indonesia
Thailand
Pakistan
Sri Lanka
Bangladesh



Capital Price
Capital Productivity Parameters
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Sweden
Norway
Japan
UK
HK
Switzerland
New Zealand
Netherlands
Denmark
Belgium
Finland
West Germany
Austria
France
Ireland
US
Singapore
Greece
Canada
Italy
Spain
Israel
Yugoslavia
Portugal
Trinidad
Bangladesh
Panama
Pakistan
Thailand
Colombia
Uruguay
Indonesia
Sri Lanka



West German Trade: 1985
log(Trade/GNP) = 2.0 - .68 log(DIST) , RSQ = .64
Trade / Partner GNP
1
0.1
0.01
0.001
100
1000
10000
100000
Distance in Miles