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MONOPOLISTIC COMPETITION AND INTERNATIONAL TRADE: RECONSIDERING THE EVIDENCE

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ABSTRACT

In this paper, we test some propositions about international trade flows that are derived from a model of monopolistic competition developed by Elhanan Helpman. We investigate whether the volume of trade between OECD countries is consistent with the predictions of a modal in which all trade is intra-industry trade in differentiated products. We then repeat the test with non-OECD countries. We also investigate whether the share of intra-industry trade is consistent with a more general theoretical model in which some, but not all, trade is intra-industry trade. Our results lead us to question the apparent empirical success of these models.

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Monopolistic Competition and International Trade: Reconsidering the Evidence

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1. Introduction.

This paper is about testing a relatively new theory of international trade. The life cycle of trade theories seems to progress as follows. First, some brilliant theorists, say Eli Heckscher and Bertil Ohlin (1991 translation), arrive at a new theory explaining international trade flows. After a while, someone comes along, say Wassily Leontief (1953). and tests the theory, finds that it doesn't do exceptionally well, and leaves matters generally mucked up. Later, someone else, say Edward Leamer (1984, 1987). comes along and sets matters straight. Maybe the theory works, maybe it does not, but by the time Leamer was done, trade economists more or less knew why the theory did or did not find support in the data

If those are the three steps in the life cycle of international trade theories, this paper is part of the second stage. This time around the theory tested is that of monopolistic competition and international trade. Instead of Heckscher and Ohlin, we have Elhanan Helpman and Paul Krugman. In this paper, we point out some puzzles and paradoxes. We do not provide many answers. At best, we pave the way for the third stage of the theory's life cycle. At worst, we leave matters confused and unsettled.

There is a long and distinguished literature examining the *theory* of international trade and monopolistic competition. The first papers were by Krugman (1979 and 1981) and Lancaster(1980). This work was further developed and expanded in Helpman (1981). and it is nicely summarized in Helpman and Krugman (1985). This line of work was in part motivated by the observation that much international trade appears to be in goods that are quite similar. While traditional factor

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endowments-based explanations of international trade did not explain this empirically relevant component of international trade, Helpman and Krugman showed that a model of monopolistic competition could.[1] There are many models of monopolistic competition and international trade, each with different sets of assumptions. In general, though, these are models in which firms produce differentiated products with an increasing-retmns-to-scale technology, while on the consumption side, consumers have utility functions that reward product diversity.

There is also a lengthy literature examining the empirical side of this topic. These studies typically construct an index of intraindustry trade and investigate what that index is correlated with.[2] While these studies are certainly interesting. their relationship to the theory of monopolistic competition and international trade is often tenuous. This is no surprise, since in many cases the empirical studies preceded Helpman and Krugman's theoretical work. Nonetheless, the theory is almost old enough to apply for a driver's license, and empirical tests closely linked to the theory remain scarce. An important exception to this is a paper by Helpman (1987) in which he developed some simple models of monopolistic competition and tested some hypotheses which were directly motivated by the theory.

Of the many papers that empirically investigate intraindustry trade, this one. titled "Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries," is especially noteworthy. It constructs hvo very straightforward theoretical models (drawing heavily on Helpman and Krugman.) These models are designed to yield empirically testable hypotheses. Taking the theory on its own terms, Helpman then asks whether the data are consistent with two predictions that fall from the theory.[3] Helpman's first hypothesis concerns the volume of trade in a model in which *all* trade is trade in differentiated products. He next asks whether the share of trade which is intraindustry is consistent with a model in which some trade is motivated by traditional factors-based explanations, while the rest of trade is motivated by a model of monopolistic

[1] Recent work by Donald Davis (1992) shows that if intraindustry trade is defined as trade in goods embodying similar factors, traditional (Ricardian) trade theory can indeed explain intraindustry trade.

[2] See Loertscher and Wolter (1980) for an early example and Greenaway and Milner (1987) for a nice overview of these studies.

[3] Helpman actually tests three predictions, but for reasons discussed in section 3, only two are relevant to our data.

competition. Using graphical methods and some simple regressions, Helpman finds that the data appear to be consistent with the models tested.

In this paper, we revisit Helpman's tests and reconsider the evidence. We do not amend Helpman's theoretical models. for we find no clear way in which to improve upon them. Rather, we apply a combination of diffennt data and different econometric methods and ask whether the data still support the theory's specific predictions. In the course of our investigation, we successfully replicate Helpman's results, pose several new puzzles and, in the end, find less than overwhelming empirical support for the theory.

The remainder of the paper is organized as follows. In section 2. a model in which all trade is motivated by monopolistic competition is presented. This model generates predictions about the volume of made. Using Helpman's data set comprised of OECD countries, we re-test the model's predictions. We also test the model using an alternative data set.[4] In section 3, a more general model in which some trade is intraindustry while the rest is traditional inter-industry (Heckscher-Ohlin) trade is described. We then test the model's predictions concerning the share of trade that is intraindustry. Section 4 concludes by summarizing the puzzles generated by the two tests of the theory. Two appendices arc. also included. In the first, we gather the derivations of the estimating equations, while the second describes our data in detail.

2. Monopolistic Competition and the Volume of Trade

We begin with the simplest model.[5] Here. all trade between countries is assumed to be intraindustry trade. Firms each produce a different variety of a differentiated product with an increasing returns to scale technology and monopolistic competition prevails. An important and testable result that falls from this theoretical set-up is that relative country size determines the volume of trade between countries. This is in contrast to the traditional factor-endowments based explanations for trade lo which "differences in relative country size . . . have no particular effect (on the volume of trade)."[6]

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[4] A summary of some preliminary results using this sort of test is found in David Hummels and James Levinsohn (1993).

[5] See Appendix 1 for a full description of this model.

[6] From Helpman, 1987, p. 64.

Helpman shows that if countries have identical and homothetic preferences and trade is balanced, then:

$$\frac{V^A}{GDP^A} = e_A[1 - \sum_{j \in A}(e_A^j)^2], \tag{1}$$

where:

V^A is the volume of trade between countries in group A;

GDP^A is the GDP of the group of counties comprising group A;

e_A is the share of group A's GDP in relation to world GDP. and

e_A^j is the share of country j's GDP in relation to group *A's* GDP.'

The RHS of (1) is a measure of size dispersion that increases as countries become more similar in size. 'This particular measure *of* size dispersion falls directly from Helpman's theoretical model. Furthermore, theory dictates exactly *how* relative country size ought to matter. Pot another way, (1) is a structural equation from a model of monopolistic competition and international trade; it is not a reduced form equation. Helpman also amends (1) and shows how the equation is altered in the presence of trade imbalances. Helpman found that correcting for trade imbalances made. virtually no difference to his empirical results. We also find this to be true. For expositional simplicity, we present only the model and results for the balanced trade case.

Helpman noted that as countries become more similar in size, the volume of trade as a proportion of group GDP should increase. To investigate this hypothesis, he selected a subset of the OECD countries. This seems a judicious choice, for if any group of countries can support the predictions of a model in which all trade is intraindustry, the OECD countries are likely candidates. Using this group of countries, he computed the left-hand-side of (1) (the volume of intra-OECD trade relative to OECD GDP) and the right-hand-side index for every year from 1956 to 1981. This yielded 26 points which he then graphed. The resulting graph showed a clear positive correlation between the ratio of intra-group volume of trade to group GDP and the index of size dispersion. That is, as country size became more similar, intra-group trade volume rose, hence confirming the theory's prediction.

[7] The derivation of (1) is provided in Appendix 1.

We found this result surprising. **The** theory that generated the estimating equation seems **quite** restrictive: every good is produced in only one country; all trade is **intraindustry; and** all **countries** have identical **homothetic preferences. Nonetheless,** the theory **appears** consistent **with the** data

We revisit this test and apply more standard econometric methods. **Helpman's** original graph of 26 points, while a prudent methodology given the small sample **size,** did not **allow** him to conduct **standard** hypothesis tests. **The** theory holds for country groups of any sire. **Rather than** aggregating over the entire OECD sample, we opt to treat each country-pair **in** each year as an observation. This yields 91 country-pair observations for each of the 22 **years** for which we have OECD data (1962-1983). **This** gives a total of **2002 observations.**

Them are. several masons why, even if the underlying theoretical model is correct, the model might not tit the data exactly in every year for every country-pair. For example. border trade, **seasonal** trade, trade restrictions **that vary** across country-pairs, language. and **cultural** ties may encourage or **discourage international trade.** Each of these. is basically **an** explanation of trade that is unique to pairs *of* **countries,** but orthogonal to GDP. (Of these. trade restrictions are the example for which this assumption is most questionable. We **will return** to this issue below.) Because these factors are country-pair specific, they can be accurately modeled as a country-pair **fixed** effect There are also idiosyncratic reasons why the **model** might not fit exactly even if the underlying theory is correct Prominent among these is **measurement** error in the volume of trade. Indexing country-pairs by i and **years** by t and taking logs of **(1),** rearranging yields:

$$ln(V_{it}) = \alpha_1 ln[GDP_{it}(1 - (e^1_{it})^2 - (e^2_{it})^2)] + \nu_i + \epsilon_{it}, \qquad (2)$$

where:

e^1_{it} is the **first** country's share of country-pair i's GDP,

e^1_{it} is tbe second country's share of country-pair i's GDP.

$\nu_i = \mu_i + ln(e_i)$ is tbe country-pair fixed effects

and ϵ_{it} is the idiosyncratic component of the disturbance term.

The term μ_i is capturing the effect of the myriad influences on trade flows that arc orthogonal to **the** included right- hand-side variable. For **example,** one might expect **the** μ_i for the Japan-Austria

[8] **e_i is considered to be a constant because we assume, like Helpman, that group GDP as a fraction of world GDP, is constant over time.**

pair to be quite small or negative whereas the μ_i for the Austria-Germany country-pair might be quite high. That is, for reasons that have nothing to do with country sire, Austria and Germany trade a lot with one another while Austria and Japan do not.

Prior to estimating (2), we first plot the right-hand-side variable against the left-hand-side variable.. This is our analog to Helpman's graphical test of the hypothesis. The plot is given in Figure 1. This plot of over 2000 country-pair-years shows a clear positive correlation between a measure of trade volume and country size.

We next estimate (2). Our base-cam estimates are for the fixed effects estimator. The results are given in the first column of Table 2 The results confirm the simple plot of the data as well as Helpman's initial findings. The theory works. With a t-statistic of 183.7. there is little doubt that the particular measure of country size dispersion dictated by the theory is quite important in explaining trade volumes. Indeed, inclusive of the fixed effects, almost 95 percent of the variation in trade volume is explained by the model.

There are, though, several reasons why the fixed effects estimate of (2) might be misspecified. For example, we are treating the μ_i's as fixed when in fact they may be random. Column 2 of Table 1 gives the estimates of (2) when a random effects estimator is employed, and it makes no difference to the results. Another possible problem is that economic theory suggests that the disturbance term ϵ_{it} will be correlated with the included regressor. That is, if exports receive a positive shock, trade volume rises. but by an accounting identity, so does GDP. Since a function of GDP appears as a regressor, we have an endogeneity problem. The standard solution to this is to employ an instrumental variables estimator. In this particular case, economic theory suggests some appropriate instruments. Following the strategy used by James Harrigan (1992), we use country's factor endowments as instruments. These are likely to be correlated with GDP and are orthogonal to idiosyncratic trade shock The results with the fixed effects instrumental variables estimator are given in column 3 of Table 2 We fmd that factor endowments am excellent instruments, for variation in factor endowments explains a very large share of the variation in GDP. While the theory suggests that the measure of size dispersion may be correlated with the idiosyncratic disturbance term, correcting for this makes very little difference. We noted above that if country-pair specific trade barriers are an important component of the fixed effect, the fixed effect may be correlated with GDP. (This would be the case if high trade barriers lead to low GDP.) In this case, the fixed effects estimates remain consistent. but inefficient, while the random effects estimates are biased. Hence, the true standard error may be smaller than the reported one, but since estimates are still very precisely estimated, this is not a cause for much concern.

Another potential explanation for the remarkable fit of (2) is that the volume of trade and group GDP may be trending upward over the period spanned by the sample. This might be the case, for example, as trade barriers fell in the European Community. It might also be the case since we have nominal dollars on the right-hand-side and left-hand-side of (2) and both arc trending upward. We investigate how robust our estimates to this concern by estimating (2) using (deterministically) detrended data. The results ate given in the fourth column of Table 1. Even after sweeping out trends and all country-pair fixed effects, the results arc still strong, as the coefficient on the measure of size dispersion is still quite precisely measured. In the final column of Table 1, we report the estimates that result from simple OLS on the detrended data. The message of this table is that Even controlling for trends and/or country-pair fixed effects. our regressions strongly support Helpman's original finding.[9]

This is surprising. We began with a simple model of monopolistic competition in which all trade is trade in differentiated products, and everyone has identical and homothetic tastes. This model implied a very specific estimating equation in which a very particular index of size dispersion was predicted to explain trade volume. And it all worked! Is the world really so simple?

To address this question, the model is re-estimated using a data set which we believe, *ex ante*, ls grossly inappropriate for a model of monopolistic competition and international trade. Instead of using the OECD countries, we create a data set comprised of Brazil, Cameroon, Cohtmbii Congo, Greece, Ivory Coast, South Korea, Nigeria, Norway, Pakistan, Paraguay, Peru. Phillipines, and Thailand. This group of countries is referred to as the NOECD countries.

Equation (2) is re-estimated using slightly different data definitions. The sample stops in 1977 instead of 1983 because several countries stopped reporting trade data in 1978. Also, we estimate the equation in levels instead of logs. This is because four of the 1456 observations of the dependent variable are almost zero. and when one takes logs, they become very large outliers, and our estimation methods are sensitive to these outliers. Column one reports the fixed effects

[9] We also estimated (2) by adding each country's GDP linearly as regressors. Results remain robust.

estimates. Even for this sample of countries, the particular measure of size dispersion suggested by the theory matters, and it matters in a precisely measured way. The t-statistic drops to 28. but by any conventional standard, thii is remarkably significant. Furthermore, the result is robust When (2) is estimated with NOECD data using random effects, fixed effects instrumental variables, and detrended data (fixed effects and OLS), the results do not vary much. If the NOECD data set is applied to (2) in logs rather than levels, the magnitudes of the coefficients are similar to those reported for the OECD dam set. While using the NOECD data set does not explain as much of the variation in the volume of trade as was the case with OECD data, the results of Table 2 still provide strong support for the theory. Put another way, if Table 2 had been presented prior to Table 1, most would agree that the model fit the data well.

What is going on here? What is it about this particular index of country size such that it so successfully explains trade volumes in such varied data sets? The theory of monopolistic competition and international trade predicts the importance of this index of country sire, but, when we apply the same index to a data set for which the theory is quite inappropriate, it still works. Perhaps what is driving tbc NOECD results also underlies tbe success of the OECD results. We do not have any definitive answers. It is true that the estimating equation would be correctly specified in any model in which countries have identical and homothetic tastes and each good is produced in only one country. Monopolistic competition is only one model which gives rise to this peculiar pattern of production. So perbaps them is another market structure, as yet unexplored, which gives rise to the same pattern of production. Perhaps too our understanding of the indeterminate role of country size in a traditional Heckscher-Ohlin model is incorrect Even if theoreticians can derive another credible model of internationally specialized production of every good, the consumption side of the model is also puzzling. Equation (2) is quite dependent on the assumption of identical and homothetic preferences across countries. Yet it is reasonable to question the validity of this assumption, especially in our NOECD data set. So far, our results, while intriguing and puzzling, are not especially enlightening. We conclude, though. that something other than a model of monopolistic competition and international trade may be responsible for the empirical success of tbe initial attempts to test tbc model.

Our results using the NOECD data set also pore a challenge to a body of literature concerning the "gravity model of international trade." (For a summary, see Deardorff (1984).) This literature started with the observation that a measure of combined GDP explained trade flows between countries quite well. For years, this was an empirical regularity in search of a theoretical foundation. The literature on monopolistic competition and international trade provided that foundation, for researchers showed that the gravity model was consistent with some models of international trade and monopolistic competition. The results presented above, though, suggest that monopolistic competition may not be what is generating the empirical success of our estimating equation.

3. A More General Approach

In section 2, we used a model of monopolistic competition to show how the presence of intraindustry trade results in a specific and testable hypothesis about the bilateral volume of trade. One of the underlying assumptions of the first section was that all trade was intraindustry. In this section, we relax that assumption and assume that some trade is intraindustry and some inter-industry. We then examine how the fraction of tie that is intraindustry varies between countries and over time.[10]

Thwretical research into the causes of intraindustry trade can be divided into "small numbers" and "large numbers" explanations, with the label referring to the number of firms. "Small numbers" models involve intraindustry trade in oligopolistic industries. These models come in many flavors as assumptions concerning homogeneity of product, the firms' strategic variable. and entry conditions vary. It is well known that the results derived io these "small numbers" models are often not robust to these varying assumptions. These models, therefore, are limited use in constructing general country characteristic hypotheses about intraindustry trade.

"Large numbers" explanations model free entry by firms into increasing returns to scale industries. We turn again to the model we fmd most convincing, Helpman (1987). He shows there that the bilateral share of intraindustry trade increases as two countries become more similar in

[10] Our study will focus on country characteristic explanations for intraindustry trade (IIT), that is, how differences across countries explain IIT. There is another, extensive literature on how intraindustry trade varies across industries within countries. The model of monopolistic competition in this paper assumes two types of industries, homogeneous and differentiated goods. Within each type, industries are identical so it makes little sense to test intraindustry trade variation across them.

factor composition."

The intuition for this is as follows. In a model with homogeneous and differentiated goods, some interindustry trade will be motivated by relative factor abundance, and some intraindustry trade will be motivated by the exchange of varieties of differentiated goods. A standard measure of intraindustry trade is the Grubel-Lloyd index. The share of intraindustry trade between country j and k in industry i is given by:

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

where X_{ijk} are exports of industry i from country j to country k. The share of intraindustry trade between country j and k. over *all* industries, is given by:

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

The numerator captures two-way trade within industries, and the denominator is the total volume of trade. More transparently, we can thii of this index as:

$$IIT_{jk} = \frac{INTRA}{INTRA + INTER'}$$

In a two country, two factor model with one homogeneous good sector and one differentiated goods sector. allow both countries to have identical capital to labor ratios. Then no trade is motivated by relative factor abundance. That is, $INTER = 0$, *and* the intraindustry *trade* index (IIT_{jk}) equals one. Now, perturb the capital to labor ratios. holding relative size constant *INTER* increases because there is now a reason for trade motivated by factor differences. *INTRA may* decrease, or may stay constant" In either case. the above index will decrease.

We were careful to note that the reallocation of capital and labor must occur holding relative size constant. We know from section 2 that relative size can have an important effect on the volume of trade in differentiated products. A reallocation of capital and labor that widened factor

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[11] See Appendix 1 for a formal statement of the 2x2x2 case. The result also holds in a model with many countries, many goods, and unequal factor rewards.

[12] See Appendix 1.

differences and also changed relative size (for example, making the two countries more equal), may actually inc- intraindustry trade.

Finally, note that this relationship between the similarity of capital-labor ratios and intraindustry trade has as much, and perhaps more. to do with traditional explanations for trade as it does with monopolistic competition models. Put another way, if we are to fmd empirical evidence of the hypothesized relationship between intraindustry trade and factor differences, it must be that trading patterns are sensitive to factor differences in a way suggested by the Heckscher-Ohlin model.

To test the relationship between factor differences and the sham of intraindustry trade, Helpman estimated the below equation on a cross section of 91 country-pairs. using separate regressions for each year from 1970-1981.

$$\begin{aligned} IIT_{jk} =& \alpha_0 + \alpha_1 log|\frac{GDP^j}{N^j} - \frac{GDP^k}{N^k}| + \alpha_2 min(log\ GDP^j, log\ GDP^k) \\ &+\alpha_3 max(log\ GDP^j, log\ GDP') + \epsilon_{jk} \end{aligned} \tag{3}$$

where IIT_{jk} is the Grubel-Lloyd index for the bilateral trade of a country-pair consisting of countries j and k, N^j is the population of country j, and an industry is defined as a four-digit SITC group. Per capita GDP is used to proxy factor composition. MINGDP and MAXGDP are included to control for relative size effects. Tbe model predicts $\alpha_1 < 0$, $\alpha_2 > 0$, and $\alpha_3 < 0$.

Helpman found that the data supported these predictions. In particular, he found a negative and significant correlation between factor differences and the IIT_{jk} index, although it weakened toward the end of his sample.[13] There are. however, two potential problems with his approach. One. Helpman uses per capita income as a proxy for factor composition. Two, he does not exploit the panel nature of his data.

Two problems are posed by the use of per capita income as a proxy for factor composition. First, it is an appropriate pmxy if there are ooly two factors of production and all goods are traded. As this is probably not the case, we would like to know to what degree a better measure of factor composition might alter the results.

Second, this approach runs afoul of a long standing debate on whether per capita income is proxying factor endowments or consumer tastes. Linder (1961) hypothesized that manufactured

[13] Specifically, the coefficient on his factor differences variable is negative and significant in the first seven years, but becomes insignificant thereafter. *Also,* the R^2 *in* the regression drops steadily from 0.266 in 1970 to .039 by 1981.

products must first be developed for home markets before they can be exported successfully. Countries with similar demand structures would develop similar goods for home use and later export. If per capita income is a good gauge of demand, then two countries with similar per capita income will have similar demand, and will produce and export similar goods. Krugman (1980) and Bergstrand (1990) have subsequently demonstrated the importance of taste differences in more rigorous models of monopolistic competition with non-homothetic demand. The empirical literature has generally interpreted differences in per capita income as a demand side phenomenon, and found good support for a negative relationship between per capita income and intraindustry trade.[14] This leads to some confusion as to whether the difference in per capita income is proxying differences in factor composition. as posited by Helpman, or demand structure, as posited by Linder. To address these potential problems with the proxy variable. we alternately employ per capita income and actual factor data to measure differences in factor composition.

We begin by estimating equations quite similar to (3) for our OECD sample separately for each year from 1962 to 1983."" Instead of using per-capita GDP differences, though. we use per-worker GDP[16] and actual capital-to-laborratios. The estimating equations. then. are given by:

$$IIT_{jk} = \alpha_0 + \alpha_1 log|\frac{GDP^j}{L^j} - \frac{GDP^k}{L^k}| + \alpha_2 min(log\ GDP^j, log\ GDP^k) + \alpha_3 max(log\ GDP^j, log\ GDP^k) + \epsilon_{jk} \quad (4)$$

$$IIT_{jk} = \alpha_0 + \alpha_1 log|\frac{K^j}{L^j} - \frac{K^k}{L^k}| + \alpha_2 min(log\ GDP^j, log\ GDP') + \alpha_3 max(log\ GDP', log\ GDP') + \epsilon_{jk,}, \quad (5)$$

where L^j is the working population of country j and K^j is j's capital stock. For expositional ease, we label $log|\frac{GDP^j}{L^j} - \frac{GDP^k}{L^k}|$, which give differences in income per worker, PWGDPDIF. Analogously, *KLDIF* will refer to the differences in capital per worker (as in (5)).

[14] See Bergstrand (1990) and the literature cited therein.

[15] Unlike the test in the section 2, we do not replicate this test using NOECD data. This is because the NOECD set, by construction, contains virtually no intraindustry trade and would therefore be of little use in studying cross-country variation in an IIT index.

[16] We use per worker GDP instead of per capita GDP, since the former seems more consistent with the underlying theory.

GDP, K (constructed capital stock), and L (labor force) come directly from, or are constructed from, Penn World Tables, Mark V data GDP and K are measured in constant 1985 international prices. See Appendix 2 for details.

Equations (4) and (5) are estimated with ordinary least squares (OLS.) IIT_{jk} is an index varying between zero and one. We apply a logistic transformation to IIT so that OLS using the transformed variable is appropriate. The results are reported in Tables 3 and 4.

Table 3 reports the results of estimating (4). The results are quite similar to Helpman's.[17] The coefficient on PWGDPDIF is negative in each sample year, but is only significant through roughly half of the sample. The coefficients on MJNGDP and MAKGDP are consistent with theory, but only MJNGDP is significant. Finally, like Helpman, the explanatory power of the regression drops steadily over time.

Just as in Helpman's study, the relationship between the sham of intraindustry trade and differences in factor composition is strongly negative in early years of the sample, but breaks down in later years. Having replicated Helpman's results, we turn to the estimation of equation (5), where per worker income as a proxy for factor composition is replaced with actual factor data

In Table 4. we see that using actual factor data changes the results considerably. The sign on the factor differences variable, KLDIF, is initially negative. but becomes positive by the end of the sample. However, in only one year (1963) is this coefficient significantly different from zero. Put another way, for 21 out of the 22 years in our sample, we cannot reject that there is no relationship between factor differences and the sham of intraindustry trade. The coefficients on MJNGDP and MAKGDP are again consistent with theory, while only MJNGDP is significant for most years. Finally, the explanatory power of the regression again drops steadily over time.

We noted above that we saw two ways in which one might improve upon Helpman's approach. The first was to use actual factor data, rather than a proxy. This change in specification changed the results in important ways. The second potential improvement is to take advantage of the panel nature of the data

[17] The variables employed here differ in three ways from Helpman's. First, we use per worker income rather than per capita income. Second, PWGDPDIF is measured in constant 1985 dollars. Helpman's study employed per capita income measured in current dollars. When we use a current dollar measure we obtain regression results very similar to Helpman's, but which differ slightly from constant dollar measures. Third, we apply the logit transform to IIT.

By estimating equations (4) and (5) year by year, we ignore the possibility that the reason the model doesn't fit exactly may be correlated over time for a given country pair. That is, for reasons outside of the model and resulting specification, intraindustry trade between Japan and the UK might always be quite low relative to the sample as a whole. Here, the theory provides some guidance. The comparative statics exercise in question takes two countries, and, holding other things constant, perturbs their relative capital to labor ratios. The natural experiment this suggests is to examine the relationship between intraindustry trade and factor differences as they change over time for a given country-pair. By looking only at cross-sectional variation, the "holding other things constant" assumption is far less tenable. This approach may be especially important if much of observed intraindustry trade is due to idiosyncratic differences between country-pairs that do not change much over time. Examples of such time-stationary idiosyncratic differences might include geography, seasonal trade, culture and language ties, and trade barriers.[18] For example, in the cross-section, we try to ascribe the variability in IIT between Germany-Austria and IIT between Japan-UK to differences in their relative factor endowments. If Germany and Austria are more similarly endowed than are Japan and the UK, we expect them to have more intraindustry trade. However, it may be that the "similar factor" effect is swamped by the fact that Germany and Austria are next door to one another while Japan and the UK ate thousands of miles away, or that Germany and Austria belong to a customs union

To examine the relationship between intraindustry trade and factor differences over time, we want to pool our 22 years into a single panel. This estimation approach requires a constant dollar measure for the factor differences variable. If nominal values are employed, currency inflation will cause this variable to trend up over time.

We first estimate a panel data version of (5) in order to pick up both cross-sectional and time series variation in $IIT_{jk,t}$. The estimating equation becomes:

$$IIT_{jk,t} = \alpha_0 + \alpha_1 log\left|\frac{K_t^j}{L_t^j} - \frac{K_t^k}{L_t^k}\right| + \alpha_2 min(log\ GDP_t^j, log\ GDP_t^k) + \alpha_3 max(log\ GDP_t^j, log\ GDP_t^k) + \epsilon_{jk,t}. \qquad (6)$$

where j k indexes a country-pair as before and t now indexes time.

[18] Previous cross-sectional studies (see Loertscher and Wolter, 1980) have tried to capture these effects with dummy variables, and consistently found them to be significant.

We also estimate a variant of (6) which includes a vector of country-pair specific fixed effects, ν_{jk}, thereby sweeping out all of the cross-sectional variation.[19] Hence we have:

$$IIT_{jk,t} = \alpha_1 log|\frac{K_t^j}{L_t^j} - \frac{K_t^k}{L_t^k}| + \alpha_2 min(log\,GDP_t^j, log\,GDP_t^k) + \alpha_3 max(log\,GDP_t^j, log\,GDP_t^k) + \nu_{jk} + \epsilon_{jk,t} \quad (7)$$

The OLS results using either income per worker or capital per worker as a regressor are reported in the first two columns of Table 5. The results differ considerably depending on which regressor is included. The income per worker variable is negative and highly significant, while the capital per worker variable is not significantly diierent from zero. These results are consistent with those reported in Tables 3 and 4. Treating the data as a panel does not appear to change the basic message of Tables 3 and 4; namely, that using actual factor data instead of a proxy matters. For both OLS regressions. the. coefficients on MINGDP and MAXGDP are consistent with theory and precisely estimated.

Fixed effects estimators are presented in the third and fourth columns of Table 5. Recall that these estimates sweep out all country-pair specific effects. The coefficient on the factor differences variable, PWGDPDIP. is now positive and quite significant, whereas before it was negative and very significant. The regression using capital per worker is slightly diierent than the OLS case but now the factor differences variable, KLDIF, is both positive and significant. For both regressions, MINGDP and MAXGDP are as before, and the explanatory power of the regressions increases substantially. It is also interesting to note that when country dummies are employed in the regressions, rather than simply mean differencing the data. the R^2 jumps to around 0.95.

Figures 2 and 3 illustrate the effects of controlling for country-pair specific effects. Figure 2 presents a plot of the intraindustry trade index against PWGDPDIF. The negative relationship is clear. Figure 3 again shows intraindustry trade plotted against PWGDPDIF but this time after mean differencing the data While some outliers remain, most of the observations lie on a line with a slope close to zero.

We speculated above that there may be reasons why the model does not fit exactly that are correlated over time for a given country-pair. Further, we noted that this could be especially

[19] This can be accomplished either by explicitly including country-pair dummies, or by differencing out country-pair means from each variable.

importantifmuchof the variability in intraindustry trade was explained by idiosyncratic differences between country-pairs. The fixed effect regression results appear to bear this out. Country-pair dummies seem to explain a tremendous proportion of the variation in our intraindustry trade index. Further, when country pair effects are swept out, the coefficient on one measure of factor differences goes from beiig insignificantly different from zero to being significantly positive. while the coefficient on the other measure goes from being a precisely measured negative estimate to a quite significant positive estimate.

Fixed effects estimation treats the ν_{ik}'s as fixed constants over time. If instead they are random variables, a random effects estimator is appropriate. The results for the random effects estimates are reported in the final columns of Table 5. Note that the random effects estimator can be thought of as lying between the within and between estimators, and hence makes use of variation both between country-pairs and within country-pairs over time. The random effects regression results are similar to the fixed effects results. Coefficients on the factor differences variables ate (still) positive and significant in both regressions. MINGDP is as before, but MAXGDP is insignificant and the explanatory power of the regressions drop a small amount. The basic message of the fixed effects estimates -- that country-pair effects drastically change the empirical role of factor differences, comes through as clearly with random effects as with fixed effects.

Prior to putting too much faith into these results, it is important to investigate how robust they are to reasonable alternative specifications. Whereas the test described in Section 2 revolved around a structural equation, this test employed a reduced form regression. That is, the theory does not dictate the appropriate specitication. It only informs one of the variables that ought to enter the specification. While we have followed Helpman in estimating Tables 3-5 using a semi-log specification, there is no theoretical justification for this particular specification, hence we experiment. We begin by estimating (6) and (7) in levels, and these results are reported in the first two columns of Table 6. Estimating in levels does not appear to change the punch-line, except that the coefficient on MAXGDP becomes positive in the fixed effects estimation, and the explanatory power drops somewhat.[20]

MINGDP and MAXGDP are included largely as size effect controls. Since we do not know how they co-vary with the factor differences variable, we want to see how the coefficients on

[20] That is, KLDIF, MINGDP and MAXGDP are measured in levels rather than logs. IIT is measured in levels throughout.

KLDIF and PWGDPDIF change when MIN/MAXGDP are omitted. Dropping MINGDP and MAXGDP does not change the sign pattern on the factor differences variable, but the R^2 drops to about zero. This indicates that the factor differences variable alone explains none of the variation in intraindustry trade. Hence, while MINGDP and MAXGDP may be of secondary importance in the underlying theory, they take front stage in the empirical work.

It may be the case that cross-sectional estimates which impose a linear relationship between KLDIF and IIT tit less well in later years because the relationship is, in fact, nonlinear. To begin to investigate this, we include a quadratic term for KLDIF and for PWGDPDIF in equations (6) and (7). For KLDIF, we find that the linear term is negative and the quadratic term is positive. Both are precisely estimated. For PWGDPDIF, the linear term is positive and the quadratic term is about zero. Evaluating the net effect of factor differences or GDP per worker differences on IIT in the neighborhood of the data indicates that ET co-varies positively with the factor and GDP per worker differences.

It appears tbat the results presented in Table 5 are robust to some other reasonable specifications. In the year by year cross-sectional regressions, and in the OLS regressions with pooled years. our measures were either negative and insignificant (PWGDPDIF), or insignificant (KLDIF). When we estimate country-pair dummies and remove all the cross-sectional variation, the coefficient for both measures becomes positive and significant. Why is this?

One explanation might be that we have very little time series variation in the right hand side variables, KLDIF and PWGDPDJF. That is, relative capital-labor ratios for a given country-pair don't change much over rime, so that when we sweep out cross-sectional variation, there is nothing left for IIT to vary against. However, an analysis of variance shows that 58 percent of the total variation in KLDJF is between country-pairs (cross-sectional variation), and 42 percent is within country-pairs (time series variation). The ANOVA for PWGDPDIF shows that 65 percent of the variation is between, and 35 percent within. In both cases, it would appear that there remains sufficient variation after mean-differencing to give interesting results.

The second explanation is that the industry classifications in the trade data are far noisier than are supposed in the simple theoretical model. Thus far, we have uncritically accepted the SITC categories as appropriate definitions for industries. There is some danger that, by measuring intraindustry trade with SITC classifications, our results are subject to an aggregation problem.

(See Finger, 1975) For example, SITC categories sometimes group goods with similar consumption uses, but different factor inputs. Trade within this "industry" would be measured as intraindustry, when in fact it is motivated by relative factor abundance. The reverse is true when SITC categories fail to group goods that ought properly be considered an industry-- i.e. SITC 7361 (metal cutting machine tools) and SITC 7362 (metal forming machine tools). When SITC classifications fail to capture appropriate industry definitions, the sign on the factor differences variable becomes ambiguous. The difficulty with this explanation is that there is no necessary reason why factor differences and intraindustry trade should be negatively correlated in cross-section, and positively correlated in time series. Put another way, were the classification problem to bias our estimates, the bias should not vary depending on whether our variation is cross-sectional or time series. Indeed, this offers another plausible reason for preferring a fixed effects estimator. If the bii in the data due to inappropriate aggregation is constant over time. it will be swept out when we mean-difference the data

A third possible explanation emphasizes the role of geography. There are several ways in which geography might play a signifiit role in intraindustry trade. First, countries sharing a border may see two-way trade in homogeneous goods, and such trade will appear in the data as intraindustry trade. This is more likely to be important for country-pairs that share a long border like the US and Canada. Second, distance may have a larger negative effect on intraindustry trade than on interindustry trade, hence closer countries may exhibit more intraindustry trade. This situation would arise if transport costs increase with distance and the elasticity of substitution between varieties of a differentiated product is greater than the elasticity of substitution between homogeneous goods. In such a case, a decline in distance has a larger (positive) effect on the volume of intraindustry trade than it does on the volume of interindustry trade.

If proximate countries have similar per capita (or per worker) income, we may see a spurious correlation between factor differences and the IIT_{jk} index in cross-&on. That is. nearby countries may have similar incomes for some unspecified reason, and they may have much intraindustry trade because of low transport costs. By estimating country pair dummies in equation (7), we sweep out the constant effect of geography on intraindustry trade. Only the correlation between intraindustry trade and factor differences, independent of geography, remains, and it is no longer negative as predicted by theory.

One can begin to evaluate the relevance of some of these explanations by examining the magnitude of the estimated fixed effects from (7). In Table 7 we report some normalized country-pair intercepts. The left panels of the table show country-pairs with large intercepts (at least one standard deviation above the mean) implying large amounts of intraindustry trade. Two things are remarkable. One. Ireland appears as one of the countries in seven of the fourteen pairs. These intercepts come from a regression which included variables for relative sire (MINGDP and MAXGDP). When we re-estimate equation (7) without the size variables, Ireland is no longer among the country-pairs with large intercepts, and in fact, can be seen as a low end outlier in some cases. This seems to indicate that size adjusts these estimates in important ways, and that Ireland, given its small size. has an especially large amount of intraindustry trade. This may be because of Ireland's tax policies with respect to multinational corporations. Another interesting thing about the first half of this table is that, of those country-pairs that do not include Ireland, nearly all share a border.

The right panels of this table contains country-pairs with very small intercepts (at least one standard deviation below the mean) and hence imply very little intraindustry trade. Fourteen of the sixteen country-pairs include either Canada, Japan, or the United States. Of the countries in our OECD sample, these are the only three outside of Europe, suggesting that perhaps oceans matter. The difficulty with interpreting these intercepts, though, is that they contain more than geographical information Anything affecting intraindustry trade that is specific to country-pairs and does not change much over time will be captured in them. This might include geography, culture and language, trade barriers, or natural resources. For example, in the results reported above, one cannot ascertain whether Canada, Japan and the US have low intraindustry trade because they are geographically distant. or because they are outside the European customs union.

To further unravel these effects and decompose exactly which factors peculiar to country-pairs might be correlated with intraindustry trade, we could construct a series of dummies for distance, and borders, and language, and customs unions, or any number of other things. However, we choose not to do so. The purpose of this paper is not to suggest and test for plausible intraindustry trade correlates. There is an already large literature investigating such correlates. Rather, we seek here only to reconsider the evidence regarding hypotheses which come directly from a rigorous model of monopolistic competition and international trade.

In this section, we tested the relationship between tbe share of intraindustry trade and factor differences. Existing studies employ per capita income as a factor proxy, utilize cross-sectional analysis. and find a negative correlation between intraindustry trade and factor differences. We find that either using actual factor data or sweeping out country-pair specific effects causes this correlation to disappear. This result appears to be robust to several specifications. We present multiple plausible explanations for this result and conclude that the effects of geography may be important. Finally, we note that country-pair effects explain a very large fraction of the variation in intraindustry trade.

4. Inconclusions

From the outset, our goal has been to test some hypotheses generated from a formal model of monopolistic competition and international trade. Previous tests had been encouraging. Studies which were not especially informed by the theory of monopolistic competition and international trade still found reasonable correlates of indexes of intraindustry trade. A study which was directly guided by the theory also found encouraging support for the theory. After reconsidering the evidence, we am not so sure. The first test presented in this paper seems based on very unrealistic assumptions, but the theory passes with flying colors. When confronted with data for which the theory is probably quite inappropriate. it still passes with high marks. The second test we conducted allows a more reasonable underlying theoretical structure, but we find little empirical support for the theory. Instead of factor differences explaining the share of intraindustry trade, **much intraindustry trade appears to be specific to country pairs.**

The results of the first test leave us genuinely puzzled. The results of the second test leave us pessimistic. for if much intraindustry trade is specific to country-pairs, we can only be skeptical about the prospects for developing any general theory to explain it. The theory of monopolistic competition and international trade is elegant and seems to address important aspects of reality. We hope our results motivate others to also investigate the empirical relevance of the theory, for, as promised in the introduction, we provide few answers.

Appendix 1

Note: Most of this appendix is taken from work by **Elhanan Helpman.** It is reported here for reference purposes only.

Theoretical background for section 2.

Consider an economy with two countries, two factors (K and L) and two sectors (X and Y.) Suppose that X and Y are differentiated products produced with an increasing returns to scale technology. Monopolistic competition prevails so that with free entry, equilibrium is characterized by a large number of firms, each producing a unique variety of X and making zero profits.

Let X and X^* denote total production of good X in the home and foreign country, respectively. The number of firms,

$$n = X/x.$$

where x is the number of home varieties and similarly for the foreign country.

Assume identical homothctic preferences and a utility function that rewards variety. Then, with costless transport, every variety of every good will be demanded in both countries. Further, each country will consume an amount of each variety proportional to its share in world GDP, GDP_w.

Let s be the home country's share in world GDP. That is,

$$s = \frac{GDP}{GDP} \quad \text{and} \qquad s^* = (1 - s)$$

where $GDP + GDP' = GDP$. Then the home country consumes spn^*x^* (= spX^*) of the foreign X good and the foreign country consumes s^*pnx (= s^*pX) of the home X good. Since y is also differentiated, the volume of trade is given by:

$$VT = s(pX^* + Y') + s^*(pX + Y).$$

The bracketed terms ate just foreign and home GDP so

$$VT = sGDP^* + s^*GDP.$$

Assuming balanced trade,

$$VT = 2sGDP^* = \frac{2 \cdot GDP.\ GDP'}{GDP} \cdot \frac{GDP}{GDP} = 2ss^*GDP. \qquad (A1)$$

The bilateral volume. of trade achieves a maximum when $s = s^*$.

Note that the same relationship between trade volume and relative size holds any time there is complete specialization in production. For example, let X and Y be homogeneous goods and assume the home country produces only X and the foreign country produces only Y. Then, $X = X + X^* = X$ and Y = Y + Y^* = Y'. Identical homothetic preferences imply

$$VT = sY^* + s^*X = sGDP^* + s^*GDP = 2ss^*GDP.$$

It is possible to generalize (Al) so that it holds for groups of countries of any size. For a group of countries, *A, we* have,

$$GDP^A = \sum_{j \in A} GDP^j,$$

where GDP^A is tbe GDP of group A. The share of country j in group A is given by

$$e_A^j = \frac{GDP^j}{GDP^A}.$$

Similarly, the share of group A in world GDP is

$$e_A^j = \frac{GDP^A}{GDP},$$

The within group volume of trade is given by:

$$\begin{aligned} V^A &= \sum_{j \in A} \sum_{k \in A, j \neq k} s^j GDP^k \\ &= \sum \sum s^j e_A^k GDP^A \\ &= GDP^A \sum_j s^j (1 - e_A^j) \end{aligned} \qquad (A2)$$

With balanced trade, one obtains:

$$s^j \triangleq \frac{e_A^j \cdot GDP^A}{GDP} = e_A^j \cdot e^A,$$

and substitution yields (1) from section 2 of tbc text

$$\begin{aligned} \frac{V^A}{GDP^A} &= e_A \sum_j e_A^j (1 - e_A^j) \\ &= e_A [1 - \sum_j (e_A^j)^2] \end{aligned} \qquad (-43)$$

This is the equation Helpman graphs to study the relationship between trade volume and relative country size in the OECD.

In the text we do not report tbc. results obtained from amending this equation to account for trade imbalances. We do report, though, that such amendments did not effect the results. To amend the estimating **equation** for trade imbalances, we employed the **following** correction **(following Helpman** exactly.) With a trade imbalance,

$$s^j = \frac{e_A^j GDP^A - T^j}{GDP}$$

where $T^j = X^j - M^j$, and one just substitutes for s^j into **(A2).** The order of the **correction** is the ratio of the trade imbalance to group GDP, and this is empirically negligible.

Theoretical background for section 3.

Now allow X to be differentiated (as before) and Y to **be** a homogeneous good produced with constant returns to scale. Assume that X is capital intensive and that the home country is relatively capital abundant. Then there will be two-way trade in the X good. Also, the home country will be a net exporter of X and an importer of Y. In figure. Al, we see the direction of trade for this example. The total volume of trade is given by:

$$VT = s^*pX + spX^* + sY - Y.$$

The volume of trade that is **intra-industry is** 2 $min(spX^*, s^*pX)$, and the share of **intra-industry trade is:**

$$IIT_{jk} = \frac{2\,min(s^*pX, spX^*)}{s^*pX + spX^* + (sY - Y)}. \qquad (A4)$$

Helpman and **Krugman** (1985) show that constant hunt-industry trade share-curves for endowments in the factor price **equalization** set are given by **figure** A2, Along the OO^* diagonal, the **intra-industry trade** share **equals** one. Factor reallocations which widen capital to labor differences without changing **relative** size **decrease** the share of **intra-industry** trade.

To see this. consider a factor reallocation from endowment point El to **E2** in **Figure A2.** We **are above** the diagonal at El, so the home country is relatively capital abundant. The move to **E2** further widens the gap **between** the home country's and the foreign country's **capital** to labor **ratios.** Also, since the move takes place along the wage-rental line, relative size is unchanged. We now ask, what happens to our **intra-industry** trade index?

Since incomes and preferences are unchanged, each country consumes exactly what it did before (the value of which is given by point **C). The** only thing that has changed is the location of production. **The** home country produces more X and the foreign country produces more Y. Since total endowments in the world economy haven't changed, $dX = dX + dX^* = 0$. Hence, $dX = -dX^*$, and similarly $dY = -dY^*$. *Since* **we** *remain in the* factor price **equalization set,** *prices are unchanged,* $dp = 0$. **Finally,** by construction, relative size has not changed, $ds = ds^* = 0$.

We wish to sign the change in (A4) that occurs as a result of this *reallocation. In the* numerator, s^*pX is **larger,** but spX^* *is* **smaller,** *so the* **numerator decreases.** For the denominator, take the total derivative to yield $s^*pdX + spdX^* - dY$. *Since* $s^* = (1 - s)$ and $dX = -dX^*$, **we** have $(1 - s)pdX - spdX - dY$ or $(1 - 2s)pdX - dY$. **The factor reallocation causes the home country to produce more** X **and less** Y, **so** $dX > 0$ **and** $dY < 0$. **Since** s **lies between 0 and** $\frac{1}{2}$, **the term in brackets** is always non-negative. The denominator in-s, so our **IIT** index **decreases** as a result of a factor reallocation which widens factor differences without changing relative size.

Appendix 2

Trade Data:

Trade data used in the first and second tests come from the United Nations Trade Database, years 1962-1983. The data are reported in four digit SITC (revision 1). The volume of trade variable used in the first test is:

$$VT_{jk} = \sum_{i}(X_{ijk} + X_{ikj}).$$

It comprises exports from country j to country *k,* plus exports from country *k to* country *j,* summed over industries *i.*

The sham of intraindustry trade was calculated using the Gmbel-Lloyd index as described in the text. An industry is defined as a four digit SITC group. All SITC categories were included in the calculation of both VT_{jk} and IIT_{jk}.

The UN trade database contains both country j's report of its exports to country *k*, and country *k's report* of its imports from j. On the assumption that the importing country keeps better track of trade flows crossing its borders, we use the importing country's reported data However, we have repeated tests in sections 2 and 3 using importer and exporter data without a change in the reported results.

Gross Domestic Product (GDP) Data:

In the first test we use GDP as reported in the World Bank World Tables. The data are converted from current year, foreign currency to current year. U.S. dollars using the exchange rate reported in the World Tables (a yearly average rate).

In the second test, we require constant dollar measures of per capita or per worker GDP to use as a factor composition proxy. Current dollar measures are inappropriate as currency inflation will cause an upward trend in the factor differences variable. As an example, at time 0, country 1 has per capita GDP of 200, country 2 has per capita GDP of 300, so that pcGDPdif=100 where pcGDPdif is the difference in per capita GDP. Allow 10 percent inflation and pcGDPdif=l 10. We use two series from the Penn World Tables, Mark V.

RGDPCH is per capita GDP, measured in constant 1985 international prices (chain index). This variable is used to construct pcGDPdif. It doesn't appear in any of the regressions we report, because it gives results which are extremely similar to PWGDPDIF (per worker GDP differences.)

RGDPW is per worker GDP in constant 1985 international prices (chain index). It is used to construct PWGDPDIF.

Using RGDPCH and POPULATION. we arrive at GDP, measured in 1985 international prices. This is used to construct MINGDP and MAXGDP.

Factor Data:

Factor data are used in the first test in the instrumental variables specification. Population data from the World Bank World Tables are used to proxy labor force. Our capital stock series has been constructed using the third method described in Appendix B of Leamer (1984). Gross Domestic Investment, exchange rates (yearly average), and the GDP deflator, are taken from World Tables. Investment flows are converted year by year into dollars. deflated using the US GDP deflator, then summed over years and depreciated appropriately.

This gives a capital stock for each year from 1962 to 1983, with accumulated investment flows denominated in the relevant year. That is. the 1970 capital stock is an accumulation of investment flows valued at 1970 prices. The World Tables Gross Domestic Investment series begins in 1960, so we assumed an initial capital stock for each country equal to 250 percent of its GDP in 1960. We assume a constantdepreciation rate of 13.3 percent. This gives an asset life of 15 years. We have constructed different series using different initial assumptions. and the first test results reported here are insensitive to these assumptions.

For the second test, we require capital stock data valued in constant dollars. Leamer (1984) notes in his data appendix that the Penn World Tables provide a useful data set for constructing a capital stock series because GDP and investment flows are comparable over time and across counties. We use the Penn World Tables, Mark V, series RGDPCH. POPULATION, RGDPW, and C Using RGDPCH, WGDPCH, and POPULATION, we get labor force. That is, RGDPCH/WGDPCH = labor force particpation rate. C is the year by year fraction of GDP that goes to investment.

Since the initial variables are already in 1985 international prices, we need only sum over investment flows and depreciate at 13.3 percent. That is.

$$K_t = K_{t-1}(1 - \textit{depreciation}) + \textit{investment}$$

. Using Penn World Tables data, we can construct an investment series going back to 1950. We assume a 1950 capital stock equal to 250 percent of GDP.

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TABLE 1
Eqn. (2) Estimates
OECD Data (19621983)

	Fixed Effects	Random Effects	Fixed Effects (Instrumental Variables)	Fixed Effects (Detrended Data)	OLS (Detrended Data)
α_1	1.236	1.236	1.255	1.092	1.18
t-stat.	183.7	183.9	159.3	31.9	44.7
R^2	.946	.944		.347	.499
# Obs.	2002	2002	2002	2002	2002

Note: Reported R^2 for the fixed effects regressions are from regressions with dummy variables, not with mean-differenced data.

TABLE 2

Eqn. (2) (in levels, not logs) Estimates

NOECD Data (1962-1977)

	Fixed Effects	Random Effects	Fixed Effects (Instrumental Variables)	Fixed Effects (Detrended Data)	OLS (Detrended Data)
α_1	.00147	.00146	.00192	.00167	.00139
t-stat.	28.33	29.01	17.48	24.33	25.29
R^2	.37	.366	–	.302	.305
# Obs.	1456	1456	1456	1456	1456

TABLE 3

Eqn. (3) OLS Estimates with GDP per Worker instead of GDP per Capita

(1962-1963)

Year	α_1	α_2	α_3	R^2
1962	-.051*	.064	-.022	.207
1963	-.067*	.064*	-.022	.251
1964	-.052*	.073*	-.026	.227
1965	-.068*	.084*	-.017	.274
1966	-.079*	.086*	-.017	.266
1967	-.060*	.094*	-.021	.237
1968	-.067*	.096*	-.022	.239
1969	-.063*	.106*	-.030	.231
1970	-.048*	.119*	-.045	.207
1971	-.064*	.117*	-.046	.221
1972	-.070*	.111*	-.033	.207
1973	-.084*	.100*	-.023	.199
1974	-.035	.103*	-.040	.130
1975	-.073	.102*	-.029	.145
1976	-.048	.094*	-.030	.079
1977	-.085	.089	-.027	.083
1978	-.092*	.073	-.009	.111
1979	-.064	.088*	-.034	.096
1980	-.041	.088*	-.051	.073
1981	-.043	.079	-.053	.069
1982	-.033	.073	-.051	.067
1983	-.047	.048	-.031	.050

The estimated regression is:

$$IIT_{jk,t} = \alpha_0 + \alpha_1 log\left|\frac{GDP_t^j}{L_t^j} - \frac{GDP_t^k}{L_t^k}\right| + \alpha_2 min(log\ GDP_t^j, log\ GDP_t^k)$$
$$+\alpha_3 max(log\ GDP_t^j, log\ GDP_t^k) + \epsilon_{jk,t}$$

An asterix indicates statistical significance at the 95% level.

TABLE 4

Eqn. (3) OLS Estimates with Capital to Labor Ratio instead of per capita GDP

(1962-1963)

Year	α_1	α_2	α_3	R'
1962	-0.042	0.073	-0.37	0.156
1963	-0.042'	0.078'	-0.044'	0.179
1964	-0.031	0.062'	-0.042'	0.156
1965	-0.017	0.094'	-0.037	0.156
1966	-0.029	0.096*	-0.042	0.158
1967	-0.029	0.102'	-0.040	0.166
1968	-0.016	0.106*	-0.047	0.158
1969	-0.008	0.116*	-0.048	0.163
1970	-0.004	0.123*	-0.055*	0.170
1971	0.007	0.122*	-0.056	0.163
1972	0.012	0.119*	-0.045	0.148
1973	0.007	0.112*	-0.040	0.133
1974	0.016	0.108*	-0.042	0.119
1975	-0.003	0.110*	-0.042	0.108
1976	0.041	0.105*	-0.036	0.081
1977	0.042	0.107*	-0.041	0.065
1978	0.013	0.090*	-0.029	0.054
1979	0.020	0.103*	-0.047	0.070
1980	0.016	0.010*	-0.057	0.065
1981	0.022	0.092'	-0.056	0.061
1982	0.040	0.089	-0.055	0.069
1983	0.04 1	0.066	-0.036	0.1348

The estimated regression is:

$$IIT_{jk,t} = \alpha_0 + \alpha_1 log|\frac{K_t^j}{L_t^j} - \frac{K_t^k}{L_t^k}| + \alpha_2 min(log\ GDP_t^j, log\ GDP_t^k)$$
$$+\alpha_3 max(log\ GDP_t^j, log\ GDP_t^k) + \epsilon_{jk,t}$$

An **asterix** indicate statistical significance at the 95% level.

TABLE 5
Eqn. (7) Estimated
(1962-1983)

Variable	no fixed effects		Fixed effects		Random effects	
PWGDPDIF	-.0618 (-9.85)		.0221 (5.23)		.0187 (4.24)	
KLDIF		.0047 (.778)		.0127 (3.47)		.012 (3.21)
MINGDP	.0986 (16.39)	.109 (15.24)	.473 (16.37)	.481 (16.60)	.298 (16.39)	.314 (16.36)
MAXGDP	-.0218 (-3.30)	-.034 (-5.15)	-.085 (-3.28)	-.091 (-3.53)	.015 (0.92)	.011 (.643)
R^2 (w/ dummies)	.147	.106	.372 .949	.365 .948	.299	.306

The estimated regression is:

$$IIT_{jk,t} = \alpha_0 + \alpha_1 log|\frac{GDP_t^j}{L_t^j} - \frac{GDP_t^k}{L_t^k}| + \alpha_2 min(log\ GDP_t^j, log\ GDP_t^k)$$
$$+ \alpha_3 max(log\ GDP_t^j, log\ GDP_t^k) + \nu_{jk} + \epsilon_{jk,t}$$

or

$$IIT_{jk,t} = \alpha_0 + \alpha_1 log|\frac{K_t^j}{L_t^j} - \frac{K_t^k}{L_t^k}| + \alpha_2 min(log\ GDP_t^j, log\ GDP_t^k)$$
$$+ \alpha_3 max(log\ GDP_t^j, log\ GDP_t^k) + \nu_{jk} + \epsilon_{jk,t}$$

T-statistics are in parentheses. The reported R^2 in the fixed effects models is that for the regression using mean-differenced data.

TABLE 6
Sensitivity Analysis of Equation 7 Estimates
(1962-1963)

Same specification as Equation 7 Except:

Variable	In Levels, Not Logs		Drop MIN/MAXGDP		Add DIF²	
	OLS	F.E.	OLS	F.E.	OLS	F.E.
KLDIF	3.06E-06	7.47E-06	-0.0019	0.00047	-0.189	-0.081
	(2.88)	(7.03)	(-0.31)	(0.11)	(-3.63)	(-3.07)
MINGDP	4.92E-10	5.84E-10			0.11	0.475
	(11.44)	(8.15)			(15.4)	(16.43)
MAXGDP	-4.18E-11	1.70E-10			-0.033	-0.085
	(-5.18)	(10.25)			(-4.91)	(-3.28)
LKDIF²					0.0123	0.006
					(3.75)	(3.58)
R^2	0.064	.196	0	0	0.112	.372
PWGDPDIF	-2.52E-05	1.40E-05	-0.071	0.015	0.347	-0.03
	(-14.22)	(6.54)	(-10.97)	(2.88)	(7.09)	(-1.10)
MINGDP	4.22E-10	5.83E-10			0.092	0.473
	(10.25)	(8.13)			(13.22)	(16.39)
MAXGDP	5.20E-12	1.98E-10			-0.0097	-0.081
	(0.62)	(11.38)			(-1.47)	(-3.13)
PWCDPDIF'					-0.027	.004
					(-6.42)	(1.95)
R^2	0.147	0.194	0.056	0.004	0.176	0.374

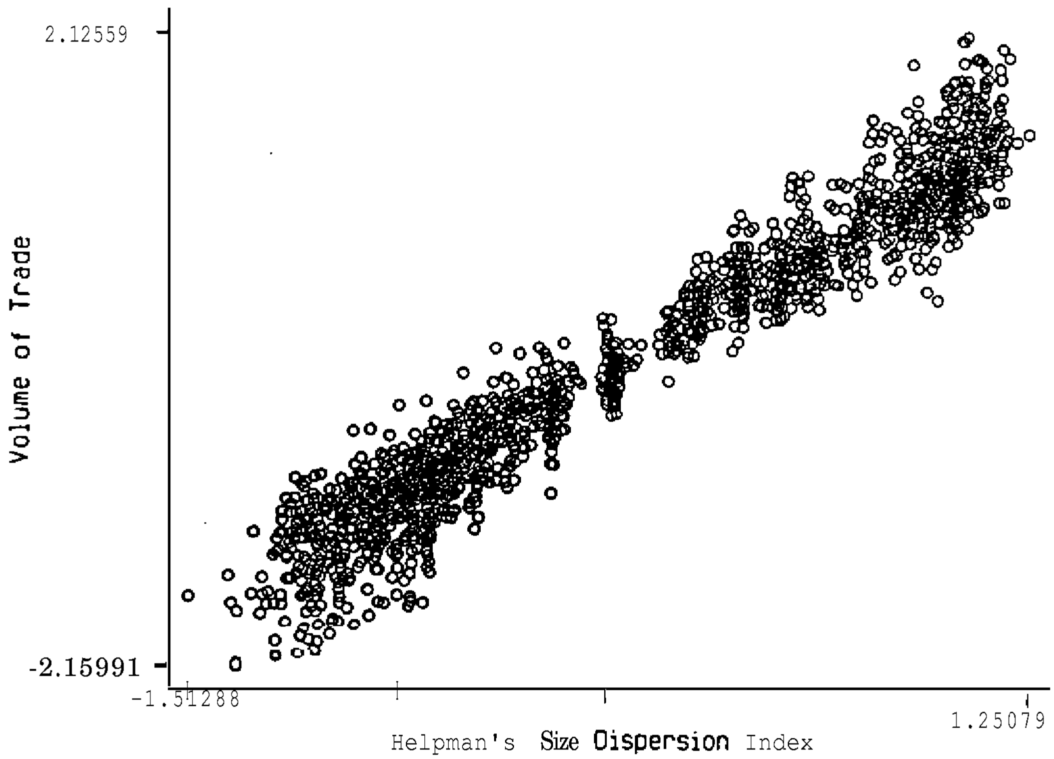
T-statistics are in parentheses.

TABLE 7
Country-Pair Outliers from Fiied Effects
Estimates of Equation (7)

Large Intercepts		Small Intercepts	
Country-Pair	Intercept	Country-Pair	Intercept
Ireland UK	1.08	Japan us	-1.09
Ireland US	0.81	Japan UK	-0.91
Belgium Germany	0.74	France Japan	-0.89
Germany Ireland	0.70	Canada Italy	-0.86
Germany Switzerland	0.64	Canada Japan	-0.85
Belgium Netherlands	0.80	Germany Japan	-0.85
Austria Switzerland	0.58	Italy Japan	-0.83
Denmark Sweden	0.56	Canada Germany	-0.79
Ireland Japan	0.54	Canada France	-0.78
France Ireland	0.53	Germany US	-0.75
Ireland Italy	0.52	Italy us	-0.72
Belgium France	0.48	Canada UK	-0.72
Canada Ireland	0.47	France us	-0.65
Austria Germany	0.46	Italy UK	-0.54
		UK US	-0.54
		Germany Italy	-0.47

Large intercepts are defined as one standard deviation above the mean, while small intercepts are one standard deviation below the mean. Intercepts were normalized around zero for purposes of this table.

FIGURE 1



2.12559
-2.15991
Volume of Trade
-1.51288
1.25079
Helpman's Size Dispersion Index

FIGURE 2

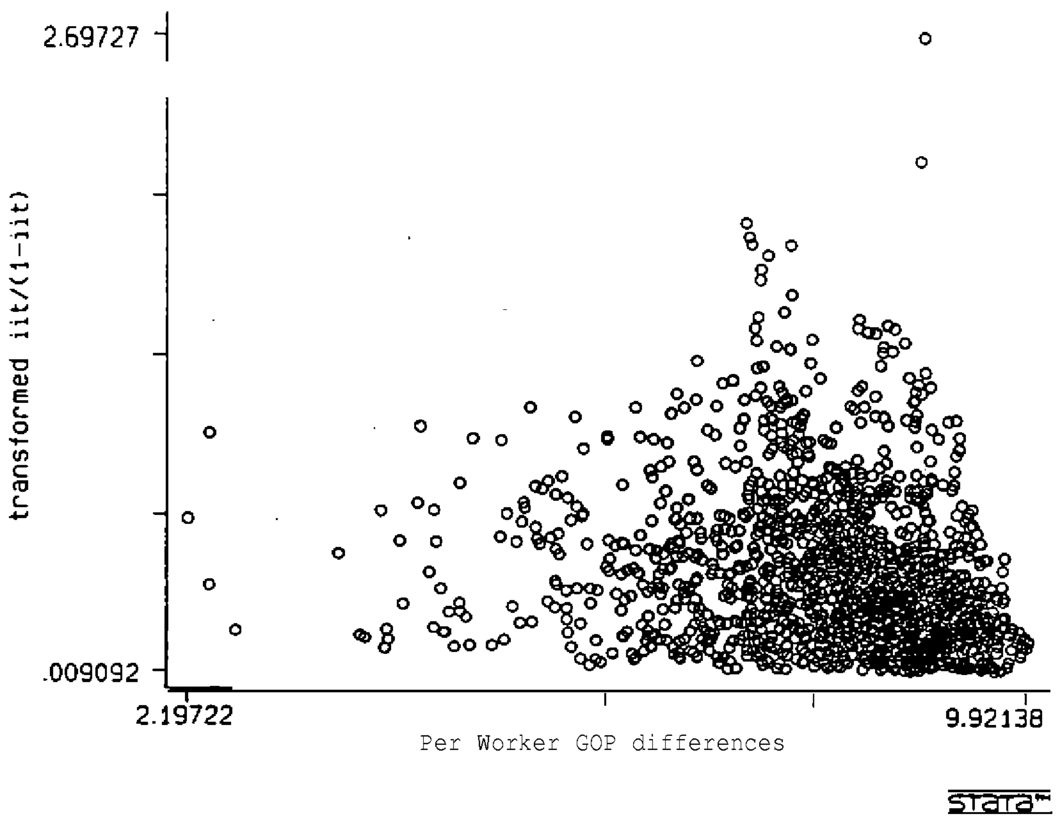
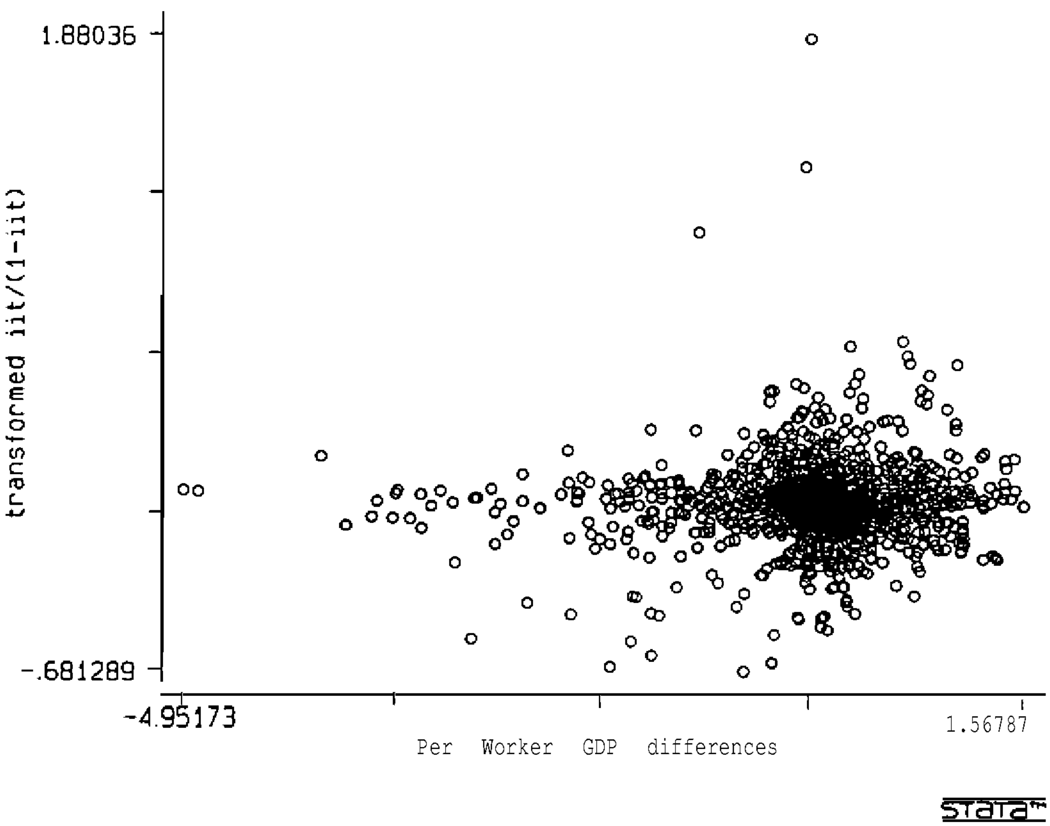

2.69727
.009092
transformed iit/(1-iit)
2.19722
9.92138
Per Worker GOP differences
stata

FIGURE 3


1.88036
-.681289
transformed iit/(1-iit)
-4.95173
1.56787
Per Worker GDP differences

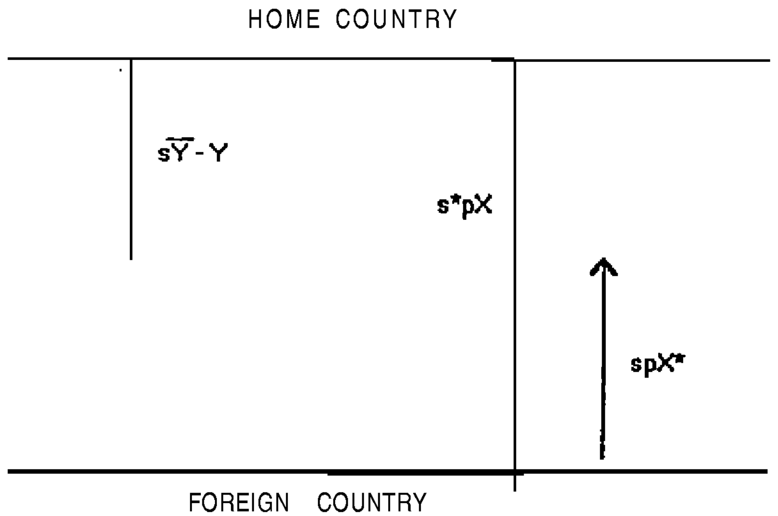


Figure AI

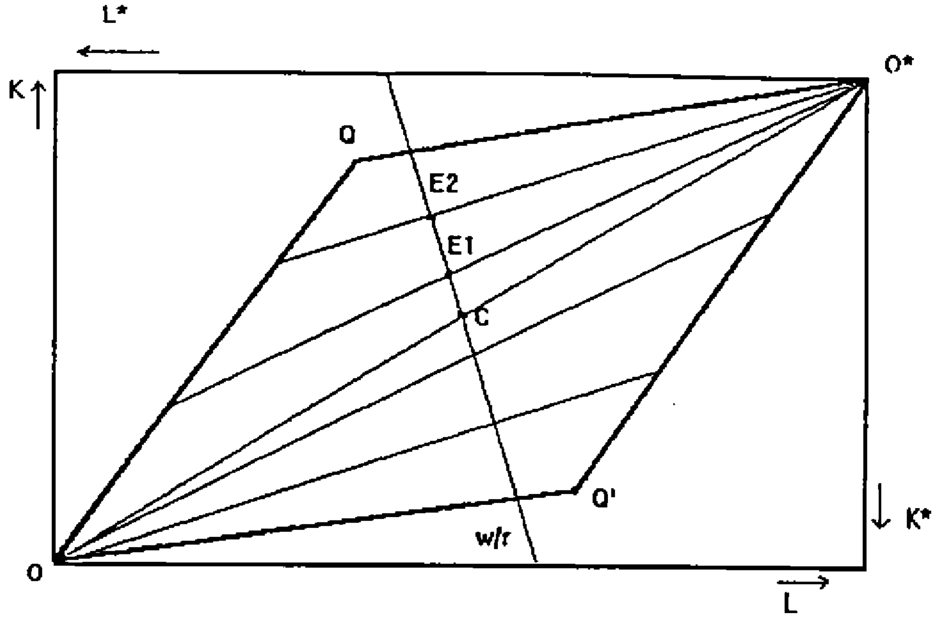


Figure A2