

NBER WORKING PAPER SERIES

**MONOPOLISTIC COMPETITION AND
INTERNATIONAL TRADE:
RECONSIDERING THE EVIDENCE**

David **Hummels**

James Levinsohn ,

Working Paper No. 4389

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 **Massachusetts** Avenue
Cambridge, **MA** 02138
June 1993

This paper is part of **NBER's research program** in International Trade and **Investment**. Any opinions expressed **are those** of the authors and not those of the National **Bureau** of Economic Research.

NBER **Working** paper #4389
June 1993

**MONOPOLISTIC COMPETITION AND
INTERNATIONAL TRADE:
RECONSIDERING THE EVIDENCE**

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 model **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.

David Hummels
Department of Economics
University of Michigan
Ann Arbor, MI 48109

James **Levinsohn**
Department of Economics
University of Michigan
AM Arbor, MI 48109
and NBER

Monopolistic Competition and International Trade: Reconsidering the Evidence

David Hummels

University of Michigan

James Levinsohn

University of Michigan

National Bureau of Economic Research

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

We are grateful to James Brander, Ron Cronovich, Alan Deardorff, Jonathan Eaton, Martin Feldstein, Gene Grossman, Elhanan Helpman, Anne Krueger, Paul Krugman, and Edward Leamer for helpful comments, suggestions, and skepticism.

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-returns-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 two 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 different 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 trade. 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** are 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** to which **"differences** in relative **country size . . . have no particular effect (on the volume of trade)."**⁶

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:

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

where:

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

GDP^A is the GDP of the group of countries 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. Put 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 size. **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**.

There are several reasons why, even if the underlying theoretical model is correct, the model might not fit 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:

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

where:

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

e_{it}^2 is the second country's share of country-pair *i*'s GDP.

$\nu_i = \mu_i + \ln(e_i)$ is the 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 are 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 size, 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-case 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 find that factor endowments are 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 are trending **upward**. We investigate how robust our estimates to **this** concern by **estimating** (2) using **(deterministically) detrended** data. The **results** are **given** in the fourth column of Table 1. Even after sweeping out trends and **all** country-pair **fixed effects**, the results are 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*, is 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, Cote d'Ivoire, 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, this 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 data 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 size, 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 the NOECD results also underlies the 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 perhaps there 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 the **initial** attempts to test the **model.**

Our results using the NOECD data set **also** pose 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 trade that is **intraindustry** varies between **countries and over time.**¹⁰

Theoretical **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** in 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 find 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:

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

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

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 find 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.

$$IIT_{jk} = \alpha_0 + \alpha_1 \log \left| \frac{GDP^j}{N^j} - \frac{GDP^k}{N^k} \right| + \alpha_2 \min(\log GDP^j, \log GDP^k) + \alpha_3 \max(\log GDP^j, \log GDP^k) + \epsilon_{jk} \quad (3)$$

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. The 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 proxy if there are only **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 1983.¹⁵ Instead of using per-capita GDP differences, though, we use per-worker GDP¹⁶ and actual capital-to-labor ratios. The estimating equations, then, are given by:

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

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

where L^j is the working population of country j and K^j is j 's capital stock. For expositional ease, we label $\log \left| \frac{GDP^j}{L^j} - \frac{GDP^k}{L^k} \right|$, 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_{jt} 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.* 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 are 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:

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

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:

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

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 different 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 different 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.

important much of **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 being **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 are (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 specification. 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, KLDF, 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** fit 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 that 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 PWGDPDIF. **That** is, relative capital-labor ratios for a given country-pair don't change much over time, 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 KLDIF 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 bias 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 significant 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-section. 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 size (**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 the 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 homothetic 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**.

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

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

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** are just foreign and home GDP so

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

Assuming balanced trade,

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

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 (A1) 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 the 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:

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

With balanced trade, one obtains:

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

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

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

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 the 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. A1, 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:

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

Helpman and Krugman (1985) show that constant **intra-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 $E1$ to $E2$ in **Figure** A2. We **are above** the diagonal at $E1$, 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 $pcGDPdif=110$. 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 constant depreciation 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 countries. We use the Penn World Tables, Mark V, series RGDPCH, POPULATION, RGDPW, and C. Using RGDPCH, WGDPC, and POPULATION, we get labor force. That is, $RGDPCH/WGDPC =$ labor force participation 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,

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

. 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.

References

- Bergstrand, Jeff (1990) "The **Heckscher-Ohlin-Samuelson** Model, the **Linder** hypothesis, and the Determinants of Bilateral **Intra-industry** Trade," *Economic Journal*, **100**, 1216-1229.
- Bowen**, Harry, Edward **Leamer**, and Leo **Sveikauskas** (1987) "Multicountry, Multifactor Tests of the Factor Abundance Theory." *American Economic Review*, 77, 791-809.
- Davis, Donald (1992) "Intraindustry Trade: A **Heckscher-Ohlin-Ricardo** Approach," *mimeo*, Harvard University.
- Finger**, Michael (1975) "Trade Overlap and Intra-industry Trade," *Economic Inquiry*, **13**, 581-589.
- Greenaway, David and Chris **Milner** (1987) "Intra-industry Trade: Current Perspectives and Unresolved Issues," *Weltwirtschaftliches Archiv*, **123**, 39.
- Grubel** H. and P. Lloyd (1975) *Intra-industry Trade: The Theory and Measurement of International Trade in Differentiated Products*. London: **MacMillan**.
- Hanigan, James (1992) "Openness to Trade in Manufactures in the **OECD**," *mimeo*, *University of Pittsburgh*, , ,
- Heckscher**, Eli and **Bertil Ohlin** (1991) *Heckscher - Ohlin Trade Theory: edited by Harry Flam and June Flanders*. Cambridge: MIT.
- Helpman**, Elhanan and **Paul Krugman** (1985) *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International Economy*. Cambridge: **MIT** Press.
- Helpman**, Elhanan (1981) "International trade in the presence of product differentiation, economies of scale and monopolistic competition: a **Chamberlin-Heckscher-Ohlin** approach," *Journal of International Economics*, **11**, 305-340.
- Helpman**, Elhanan (1987) "Imperfect Competition and **International** Trade: Evidence from Fourteen Industrial Countries." *Journal of the Japanese and International Economies*, **1**, 62-81.
- Hummels, David and James **Levinsohn** (1993) "Product Differentiation as a Source of Comparative Advantage?," *American Economic Review, Papers and Proceedings, forthcoming*, , .
- Krugman**, Paul (1979) "Increasing Returns to Scale, Monopolistic Competition and International Trade." *Journal of International Economics*, **9**, 469-479.
- Krugman**, Paul (1981) "Intra-industry Specialization and the Gains from Trade," *Journal of Political Economy*, **89**, 959-973.
- Lancaster**, Kelvin (1980) "Intra-Industry Trade under Perfect Monopolistic Competition.," *Journal of International Economics*, **10**, 151-175.
- Leamer**, Edward (1984) *Sources of International Comparative Advantage*. Cambridge: MIT Press.
- Linder**, Stefan (1961) *An Essay on Trade and Transformation*. New York: Wiley.

Loertscher, R and Wolter, F. (1980) "Determinants of Intra-industry Trade: Among Countries and Across Industries," *Weltwirt Archiv*, 8, 280-293.

TABLE I					
Eqn. (2) Estimates					
OECD Data (1962-1983)					
	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
R²	.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 ²
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	0.041	0.066	-0.036	0.1348

The estimated regression is:

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

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:

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

or

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

T-statistics are in parentheses. The reported R² 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 DIF ²	
	OLS	F.E.	OLS	F.E.	OLS	F.E.
KLDIF	3.06E-06 (2.88)	7.47E-06 (7.03)	-0.0019 (-0.31)	0.00047 (0.11)	-0.189 (-3.63)	-0.081 (-3.07)
MINGDP	4.92E-10 (11.44)	5.84E-10 (8.15)			0.11 (15.4)	0.475 (16.43)
MAXGDP	-4.18E-11 (-5.18)	1.70E-10 (10.25)			-0.033 (-4.91)	-0.085 (-3.28)
LKDIF ²					0.0123 (3.75)	0.006 (3.58)
R ²	0.064	.196	0	0	0.112	.372
PWGDPDFIF	-2.52E-05 (-14.22)	1.40E-05 (6.54)	-0.071 (-10.97)	0.015 (2.88)	0.347 (7.09)	-0.03 (-1.10)
MINGDP	4.22E-10 (10.25)	5.83E-10 (8.13)			0.092 (13.22)	0.473 (16.39)
MAXGDP	5.20E-12 (0.62)	1.98E-10 (11.38)			-0.0097 (-1.47)	-0.081 (-3.13)
PWCDFDIF'					-0.027 (-6.42)	.004 (1.95)
R ²	0.147	0.194	0.056	0.004	0.176	0.374

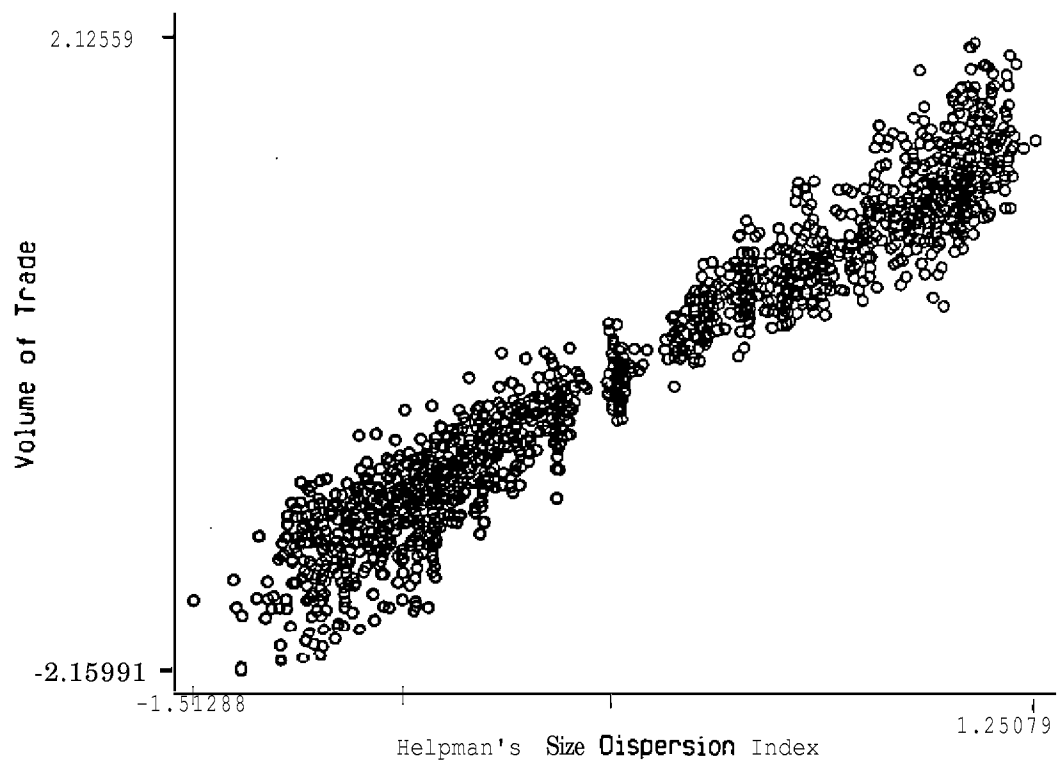
T-statistics are in **parentheses**.

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

Large Intercept		Small Intercept	
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

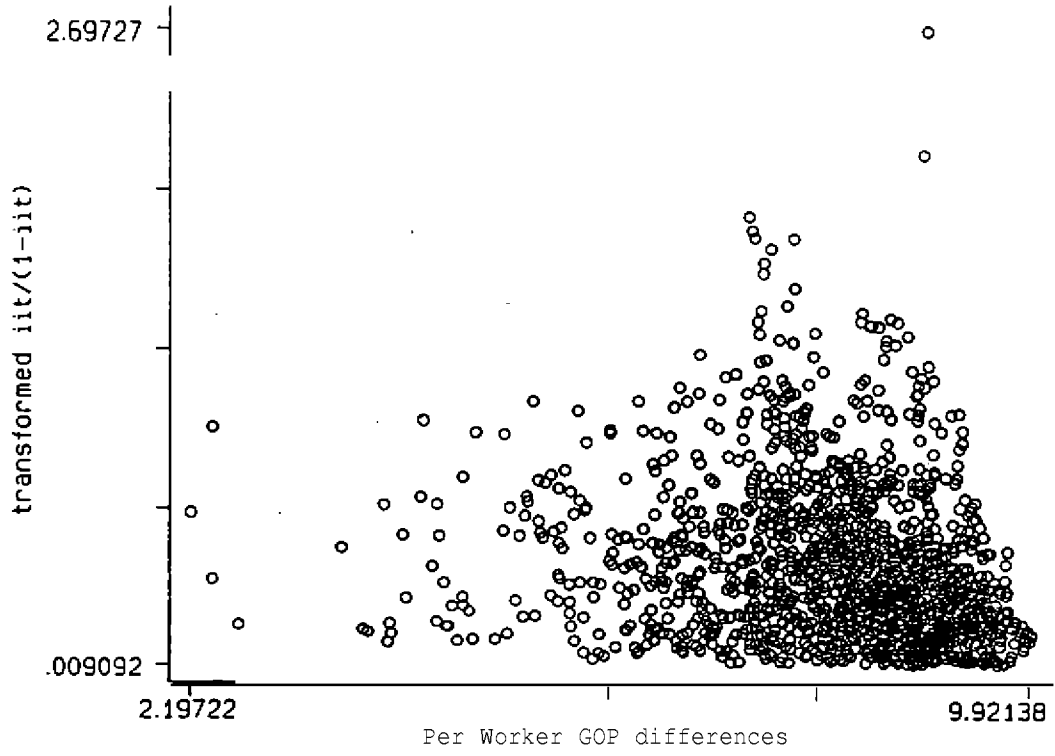
Large intercepts are defined as one standard deviation above the mean, while small intercepts are one standard deviation below the mean. Intercepts were normalized around zero for purposes of this table.

FIGURE 1



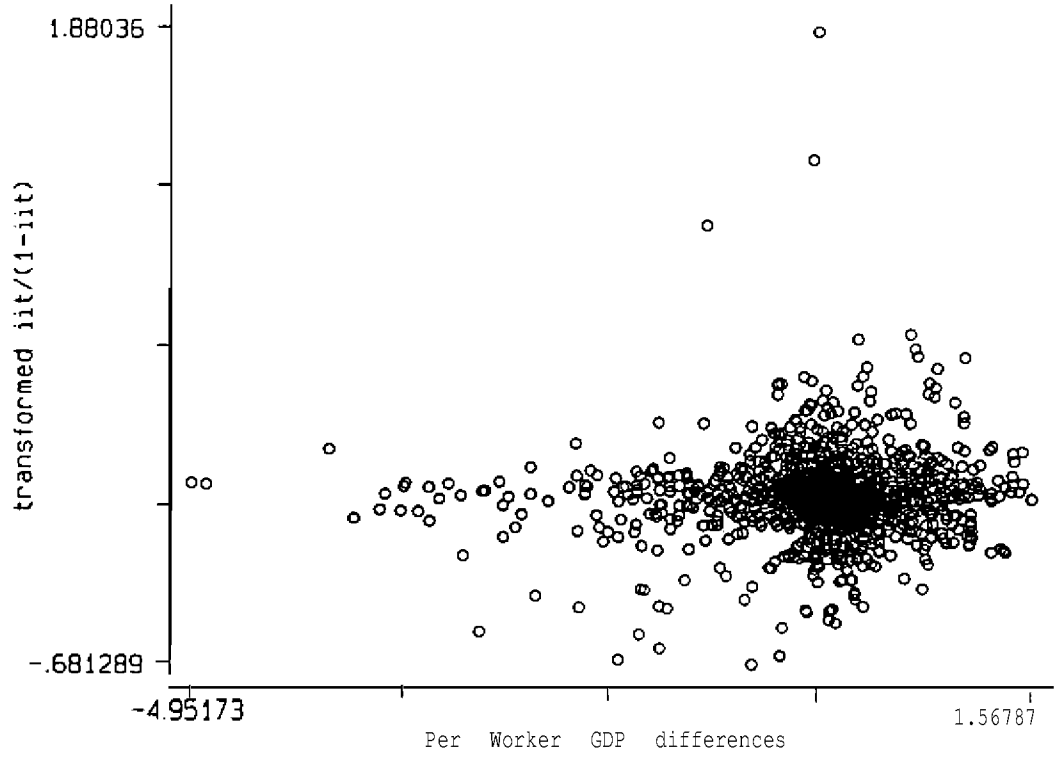
Stata™

FIGURE 2



stata™

FIGURE 3



STATA™

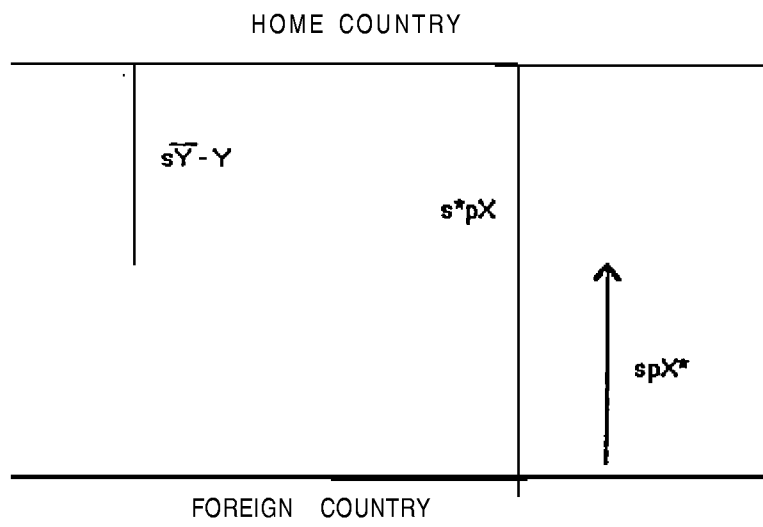


Figure A1

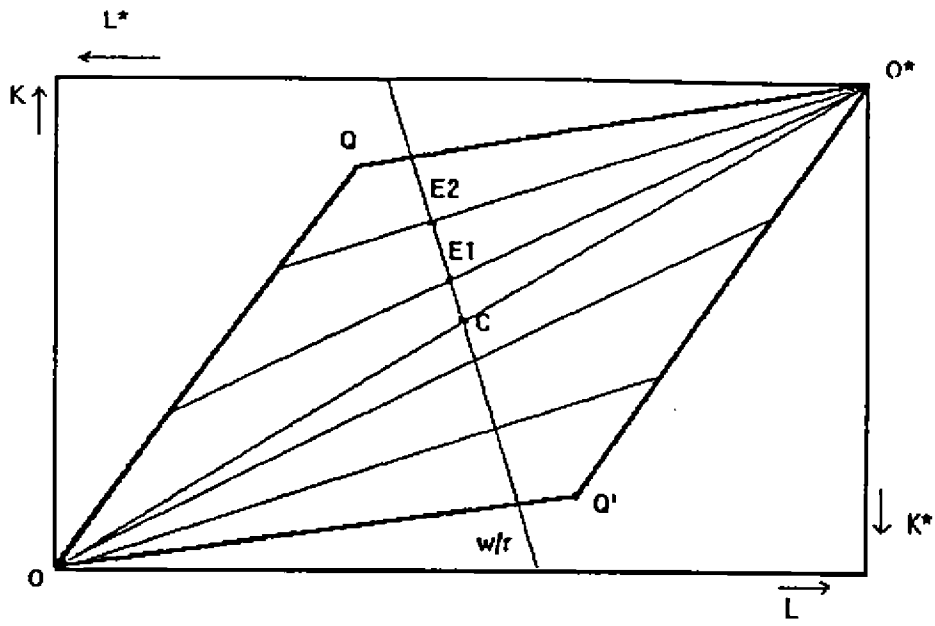


Figure A2