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EXAMPLES FROM PURE THEORY

Alan V. Deardorff

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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University of Western Ontario
The Directions of Developing Countries Trade:
Examples from Pure Theory*

by
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The University of Michigan
Revised
April 1, 1983


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I. Introduction

There is substantial empirical evidence that many developing countries—by which I perhaps optimistically mean those countries of the world that are neither most nor least developed—tend to export different kinds of goods to their more developed and less developed trading partners. In particular it has been observed that countries tend to export more capital intensive goods to countries that are less abundantly endowed with capital than themselves, while at the same time exporting different, less capital intensive goods to more capital abundant countries.\(^1\) This intuitively plausible pattern of trade is of course absent from most of the pure theory of international trade, which typically deals with a world of only two countries. Even such recent contributions as have dealt with multiple countries have usually focused primarily on total trade and patterns of specialization, and have dealt only tangentially if at all with bilateral patterns of trade.\(^2\) Hilton (1981), on the other hand, did look at bilateral trade, but only to compare the characteristics of a country’s exports and imports vis à vis a single trading partner. He did not, in his theoretical analysis, compare exports to different trading partners as I do here. We therefore lack a good understanding of whether the standard models of modern trade theory either permit or require this intuitive pattern of bilateral trade. My purpose in this paper is to contribute to such an understanding.

It turns out that I am unable to show that the intuitive pattern of trade must arise in trade models with any generality. Indeed, I find several counterexamples in which just the opposite, counterintuitive pattern of bilateral trade emerges. However, in most of the more plausible cases the intuitive trade pattern does arise, and these cases do provide useful tools for explaining it.

\(^{1}\) An early observation of this pattern of bilateral trade was found for Japan by Tatemoto and Ichimura (1959) and reaffirmed by Heller (1976). Other evidence of this pattern can be found for India in Khanna (1982a), which also includes references to other work on this subject.

\(^{2}\) See, for example, Jones (1974), Krueger (1977), and Deardorff (1979, 1982)
My procedure in the paper is therefore to work through a number of examples of specific trade models. Some of these illustrate the plausibility of the intuitive result, others the possibility of its opposite. In this way I hope to draw attention to certain features of the world economy that may account for the fact that the intuitive trade pattern is so often observed.

Let me begin by explaining why I have called the observed pattern of trade "intuitive," and why at the same time this intuition does not provide a sufficient explanation. We understand that trade derives from comparative advantage. Comparative advantage derives in turn, in a Heckscher-Ohlin framework, from relative factor endowments and relative factor intensities of traded goods. It is plausible, then, and correct in theory, that if a country is able to produce more than one good with different factor intensities, the size of its comparative advantage in these goods (measured by differences in relative autarky prices), compared to countries less developed than itself, will be greatest in the more capital intensive of the goods. Thus one might expect it to export relatively more of these goods to such countries, while exporting more of its more labor intensive products to more developed countries. If the extent of trade, and not just its direction, were positively related to the size of comparative advantage, then this would presumably occur.

For a variety of reasons, however, standard models of trade such as the Heckscher-Ohlin Model do not imply such a quantitative relationship between trade and comparative advantage.\(^3\) The reasons for this include both general equilibrium effects of trade on factor prices—effects which tend to remove the very cost differences which give rise to trade—and the fact that supply functions may be sufficiently elastic that quantities traded depend more on demand than on supply. Therefore while the observed pattern of trade can be explained intuitively in terms of comparative advantage, a more careful explanation, if it can be found, must focus on how supplies

\(^3\) See Deardorff (1983) for more discussion of this point, which has induced some investigators, beginning with Harkness and Kyle (1975), to use binary-variable econometric techniques for empirical applications of the theory.
and demands interact in trade.

One author who has addressed this issue in theoretical terms, if only as a byproduct of her more extensive analysis of patterns of specialization, is Krueger (1977, p. 21). In a Heckscher-Ohlin (H-O) model with many goods and countries, two factors, and internationally unequal factor prices, she states the following as one of several predictions of the model:

Insofar as the country's manufactured exports differ between the two groups of destinations, the capital intensity of exports will be greater to the more labor-abundant area, and conversely.

In a footnote she explains this result on the grounds that "labor-abundant manufacturing sectors will need less of a transport-cost barrier to enable their firms to compete with the labor-intensive commodities." Thus she draws attention to transport costs as crucial for determining the bilateral pattern of trade and implying the intuitive result. I will show that the existence of transport costs is neither necessary nor sufficient for explaining the intuitive pattern of trade. Nonetheless I agree with Krueger that the structure of transport costs does provide the most insight as to why the observed pattern of trade occurs.

Khanna (1982b) expands somewhat on Krueger's theoretical analysis and explains her conclusions more fully. Khanna's examples of trade patterns are essentially the same as those I will discuss later in this section.

The structure of this paper, together with a preview of the results, is as follows: In the rest of this introductory section, I will show in a simple and familiar example how the intuitive pattern of trade might arise with free trade, but also how one might just as well find each country exporting the same bundle of goods to all foreign markets. To assess the likelihood of these two outcomes, I turn in section 2 to a multicountry extension of Dornbusch, Fischer, and Samuelson's (1980) version of the Heckscher-Ohlin model with a continuum of goods. In this model with free trade and unequal factor prices, I show that the same goods are exported to all countries.
However one can get something like the intuitive trade pattern by introducing transport costs. This is easily done, and the resulting model readily implies that countries will export a more capital intensive range of goods to less capital abundant neighbors and vice versa.

In section 3 I return to a model with a discrete number of goods to show how differences in demands can give rise to distinctly counterintuitive patterns of trade. That is, countries in some circumstances may export more capital intensive goods to countries that are more capital abundant than themselves, rather than less. Since these differences in demand could arise from the price differences that are caused by transport costs, the latter are clearly not a compelling reason for the intuitive trade pattern.

In section 4 I suggest that transport costs may give us greater insights about bilateral trade when we account for the fact that they differ across countries with whom a particular country might trade, and perhaps also that they differ across goods. To this end I examine several models that allow such differences in the extreme form of bilateral transport costs that are either zero or prohibitive. Depending on the pattern of these transport costs, both intuitive and counterintuitive trade patterns may again emerge, but the cases that correspond best to what I perceive as the real world do involve the intuitive pattern of trade. Indeed the last of these models—what I call a World of Tiers—strikes me as quite a plausible yet simple model of trade both between and within the North and South, and it implies the observed intuitive pattern of their trade quite readily.

Throughout the paper, while the numbers of goods and countries in the examples will vary, the number of factors will remain at two and they will be identified as capital and labor. While I recognize, of course, that more factors must be considered for a full explanation of trade, the two factor assumption focuses attention most precisely on the issue of bilateral trade that is the subject of this paper. Also one could, as done by Krueger (1977), augment any of these models by adding additional factors, together with additional sectors to which these factors, rather than
capital, are specific. The results obtained here would then still apply for the sectors that employ capital and thus may be said to refer to that portion of trade that involves manufactured goods.

A second assumption that I will retain throughout is that factor prices are not equalized across countries. This, as also argued by Krueger (1977), is the natural assumption for dealing with countries of vastly different levels of development. The implication of complete specialization is also less severe in a model of many goods than in the traditional two-good case, and is ameliorated still further when transport costs are considered. Still one should bear in mind that some of the "countries" considered here may better represent groups of countries with endowments so similar that they enjoy factor price equalization within groups.

Finally, I use throughout the usual assumptions of Heckscher-Ohlin trade theory. All goods are final goods and are produced with neoclassical, constant-returns-to-scale technologies in competitive industries. Interesting models do exist that drop any or all of these assumptions, as surveyed in Jones and Neary (1983). I prefer, however, to begin the discussion of bilateral trade flows in the more traditional context.

To begin, then, with the analysis, consider Figure 1 which illustrates a possible configuration of unit-value isoquants and unit-isocost lines for three countries, four goods, and two factors. In this example free trade world prices of the four goods, which determine the locations of the four isoquants drawn, are such that production of more than two goods in a single country is impossible. Instead, given the factor endowment ratios of the three countries,

4. See Deardorff (1979) for more on the use of unit-value isoquants--the "Lerner-Pearce Diagram"--to illustrate trade equilibria with many goods and countries. The isoquants shown are drawn for particular given values of the prices of the goods relative to a common numeraire. They represent quantities of the goods worth exactly one unit of the numeraire at those prices: $X_1 = 1/P_1$, $X_2 = 1/P_2$, etc. Unit-isocost lines in any country cannot pass above any unit-value isoquant in that country and must be tangent to the isoquants of any goods that the country produces.
Specialization Matrices:

<table>
<thead>
<tr>
<th></th>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>$x_4$</th>
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<tbody>
<tr>
<td><strong>A</strong></td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>B</strong></td>
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<td>X</td>
<td>X</td>
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<tr>
<td><strong>C</strong></td>
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<td>X</td>
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</table>

**The Intuitive Case**

<table>
<thead>
<tr>
<th></th>
<th>$x_1$</th>
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<td><strong>B</strong></td>
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<tr>
<td><strong>C'</strong></td>
<td></td>
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<td></td>
<td>X</td>
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</tbody>
</table>

**The Neutral Case**

Figure 1
indicated by the rays OA, OB, and OC respectively, A can produce goods $X_1$ and $X_2$, B goods $X_2$ and $X_3$, and C goods $X_3$ and $X_4$. Relative factor prices in each country are shown by the slopes of the isocost lines tangent to the isoquants of the two goods each country is capable of producing.

To deduce a particular pattern of trade from this configuration, assume that the four goods are demanded in roughly equal proportions in all countries. Then, given the factor endowments shown, each will produce more than it can use of the products in which it specializes, and the pattern of exports will be the same as the pattern of production. This is shown in the first specialization matrix in Figure 1. Assuming that countries import only goods that they do not export (more on the alternative assumption later), the pattern of exports of country B is precisely the intuitive pattern described earlier: Country B exports both good $X_2$ and good $X_3$, exporting the more capital intensive good $X_3$ only to the less capital abundant country A and the less capital intensive good $X_2$ to the more capital abundant country C.

That the intuitive trade pattern need not arise, however, can also be shown with the aid of Figure 1. Suppose that the factor endowment ratios of the extreme countries A and C were even more extreme than before, given now by the rays OA' and OC'. To make this feasible, B must now be sufficiently large in size compared to A and C. With the same prices as before, countries A and C must now completely specialize in production of goods $X_1$ and $X_4$ respectively. For example, factor prices in A must be given by the tangent to $X_1$ where it crosses OA', and will not support production of any other good. The pattern of specialization is therefore as shown in the lower specialization matrix in Figure 1. As the only producer of $X_2$ and $X_3$, country B will now export both goods to both countries. Indeed if demands for the goods are identical, as is certainly possible since the countries face identical prices in free trade, then B will export $X_2$ and $X_3$ in the same proportions to both A and C. There will be no difference at all in the composition of B's
bilateral exports in the two directions. This pattern of trade is not the intuitive one that has been found empirically, though it is not strictly counterintuitive either. I will call it the neutral case.

Which is the more likely of the two cases just observed is difficult to say in a model with a discrete number of goods. As the examples above suggest, much depends on the particular configurations of factor endowments, country sizes, and factor intensities. Much of this becomes clearer, however, if one moves to the natural generalization of this model in which there is a continuum of goods as proposed by Dornbusch, Fischer, and Samuelson (1980).

2. The Heckscher-Ohlin Continuum Model

Assume now, following Dornbusch, Fischer and Samuelson (1980), or DFS, that there are infinitely many goods, indexed by z for all z on the unit interval, [0,1]. Each good still has its own neoclassical, constant-returns-to-scale production function using inputs of capital and labor, and in fact it is still possible to use unit-value isoquants to characterize their production. Given the factor prices, w and r, of labor and capital respectively, the cost-minimizing per-unit labor and capital requirements for producing good z depend on the ratio \( \nu = w/r \):

\[
\begin{align*}
\hat{a}_L(z) &= a_L(z;\nu) \\
\hat{a}_K(z) &= a_K(z;\nu)
\end{align*}
\]

I will assume that there are no factor-intensity reversals between any pair of goods, and therefore that the ordering of the goods in terms of z can also be their ordering in terms of capital intensity. That is

\[
K(z;\nu) = a_K(z;\nu)/a_L(z;\nu)
\]

is strictly increasing in z.
DFS, in a model of this sort with free trade and only two countries, added explicit assumptions about demand and wrote out all of the conditions needed to determine a complete general equilibrium. For my purposes I will take such an equilibrium as given and characterize it only sufficiently to determine the pattern of trade. However the nature of the problem requires that I go beyond DFS by considering more than two countries. Also I will treat separately the two cases of free trade and transport costs.

2.1 Free Trade

Given the factor prices that prevail in equilibrium in various countries, the pattern of specialization under free trade is completely determined by the unit costs of the goods that these factor prices imply. In general these costs are given by

\[ c(z;w,r) = w_a \lambda (z;w/r) + r a_k (z;w/r) \]

With free trade, each country will produce only those goods for which its costs are at least as low as elsewhere. It is useful, therefore to graph these cost functions as they depend on \( z \) for each of several countries with different factor prices.

The shapes of such graphs are quite arbitrary in general, since units of measurement of the goods need not be comparable. However for simplicity I will draw them as straight lines since linearity is possible in at least one special case, and since straight lines do have the one essential property that will be used in deriving results in this paper. That property is that they cross, at most, only once. That the cost functions, whatever their shapes, must have this property is easily seen from the geometry of unit-value isoquants and unit-isocost curves.

5. Unit cost can be linear in \( z \) if technologies are Leontief, so that \( a_L(z;v) = a_L(2) \) and \( a_K(z;v) = a_K(2) \) both independently of \( v \). Then if units of the goods are chosen so that \( a_L(2) = 1 \) for all \( z \), and if \( k \) is linear in \( z \), then \( c(z) = w + r(k(z)) \) is also linear in \( z \).
Consider, then, the cost curves for several countries with different factor prices. To be consistent with free-trade equilibrium, these factor prices must give each country a cost advantage in at least some goods. Otherwise trade could not be balanced. Such a case is shown in Figure 2 for four countries, A, B, C, and D. Wage-rental ratios are lowest in country A, next lowest in B, and so on. It follows that the cost curves are, as drawn, steepest in country A and become flatter as wage-rental ratios rise across countries.\(^7\)

With free trade the pattern of specialization and trade is now obvious. As is true with a discrete number of goods in Krueger (1977) and Deardorff (1979), each country specializes in a range of goods that are contiguous in terms of their capital intensities. The most labor-abundant country, A, produces a group \(X_1\) of the least capital-intensive goods. Country B produces another group, \(X_2\), that is somewhat more capital intensive, with no overlap between the two groups except for the single good \(z_1\). A similar relationship holds for the products of C and D, all of which is shown in the specialization matrix in Figure 2.

What is notable about this pattern of production is that virtually all goods are produced in

\[\text{---------}\]

6. To see this, suppose that a particular good, \(z_0\), costs the same at two different sets of factor prices. Then a single isoquant of \(z_0\) will be tangent to the unit-isocost lines for both sets of factor prices. Unit costs of all other goods can be inferred from the prices that would be needed to place their unit-value isoquants just tangent to these two isocost lines. From the geometry it is clear that these prices differ systematically depending on whether goods are more, or less, capital intensive then \(z_0\). Drawing the cost curves as linear in \(z\) is a simple way of assuring that they have this property and does not, as it turns out, influence any of the other results to be obtained here.

7. This relationship is obvious in the Leontief-technology case of footnote 5, since the flatter curves (lower \(r\)) also have a higher intercept (larger \(w\)). It can also be shown to be true in general by pursuing the argument of footnote 6.
Specialization Matrix:

<table>
<thead>
<tr>
<th></th>
<th>$X_1$</th>
<th>$X_2$</th>
<th>$X_3$</th>
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<tr>
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<td>D</td>
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</table>

Figure 2
only one country and are therefore exported by that country to all others. Cases like the first considered in Figure 1 are essentially eliminated by the expansion of the model to a continuum of goods. With free trade each country exports the same range of goods to all other countries. What I described in Figure 1 as the neutral pattern of bilateral trade is the only one that can arise in the continuum model with free trade, at least as long as demands for the goods are everywhere identical.⁸

2.2 Transport Costs

The continuum model is particularly well-suited to the incorporation of a simple form of transport costs.⁹ Suppose, following Samuelson (1954), that transport costs are given by the "iceberg" model: a fraction of each good is used up in transport. Formally, I will assume in this section that this fractional transport cost is the same for all goods and for all countries both as origins and as destinations. Thus there is a single number, g, between zero and one, that represents the fraction of any good that survives when it reaches its destination in trade.

Adding this assumption to the model is quite simple. Given the (different) prices of factors in each country, cost curves such as those in Figure 2 still obtain."¹⁰ Now however a country will

---

8. It may be suspected that the neutrality of the trade pattern here depends on the assumption that products are homogeneous. To see that this is not the case, consider an Armington (1969) model in which all products are differentiated by country of origin. Here each country will produce all goods. But with free trade and identical homothetic preferences, the pattern of trade will be neutral even with only a finite number of goods.

9. See Dornbusch, Fischer and Samuelson (1977) where they used transport costs in a Ricardian continuum model to show how the status of goods as traded and nontraded can be made endogenous.

10. I am not saying that transport costs could be changed without altering the equilibrium factor prices in various countries. I am not trying to derive equilibrium, but merely to characterize some aspects of it. What I am saying, therefore, is that with transport costs there will exist some set of equilibrium factor prices, and these will imply cost curves with the same qualitative properties as those in Figure 2.
import a particular good only if it is produced elsewhere for less than \( g \) times its cost of production domestically. Only then will the cost advantage of the import be sufficient to overcome the barrier of the transport cost.

To see the pattern of specialization and trade in this situation, look at Figure 3. There cost curves like those in Figure 2 are reproduced together with relevant portions of each curve multiplied by \( g \). The fraction \( g \) is taken to be rather close to one so as to avoid the complications of completely nontraded goods and countries that do not trade. Instead, in the example shown, each country exports some goods and imports others, and all goods are traded by somebody.\(^{11}\) In comparison with the free trade case of Figure 1 the new feature introduced by transport costs is that each country now has a group of goods that it neither exports nor imports. Such goods are produced exclusively for the domestic market, even though they are being traded elsewhere in the world by other pairs of countries. In the specialization and trade matrix below the figure, these goods are indicated with the letter \( P \), for "produced," in contrast to \( X \), which indicates that a good is both produced and exported.

Thus consider for example, goods in the group \( X_2 \) between \( z_1 \) and \( z_2 \). These goods are most cheaply produced in country A, as is evident from its cost curve, \( C^A \), relative to the others in that region. However \( C^A \) does not lie below \( gC^B \), and it follows that demanders in B can get these goods more cheaply from their own domestic producers in B than they can import them from A, given that somebody must pay the transport cost. Thus the group of goods \( X_2 \) is produced in both A and B, but only exported by A. Since C and D do not produce these goods, both must import them from A.

\[\text{\textsuperscript{11}}\text{It is possible to get nontraded goods in this model and they turn out to be ones of intermediate factor intensity. A better model of nontraded goods, however, would surely rely on differences in transport costs across goods.}\]
Specialization and Trade Matrix:

<table>
<thead>
<tr>
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<th>$x_1$</th>
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<tr>
<td>$A$</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>P</td>
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<td>X</td>
<td>X</td>
<td>P</td>
</tr>
<tr>
<td>$D$</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>P</td>
<td>X</td>
</tr>
</tbody>
</table>

$X$ = Exported  
$P$ = Produced (and not traded)  
(blank) = Imported  

Figure 3
Now consider the complete pattern of production and trade of a country, such as B, that is of intermediate factor abundance. It produces all goods in the interval \((z_1, z_6)\). Of these, it exports only the smaller interval \((z_2, z_5)\). Finally, of these, it exports only the interval \((z_3, z_4)\) to all other countries. The rest of its exports go only to a subset of the other countries of the world. The more labor intensive of its exports—the group \(X_3\)—go only to more capital abundant countries. Its more labor abundant trading partner, country A, can compete effectively in these industries on its own (A's) domestic market given the protection afforded by transport costs, even though A cannot compete anywhere as an exporter. Country A imports only the more capital intensive of B's exports, groups \(X_4\) and \(X_5\).

At the other extreme, B's more capital intensive exports, group \(X_3\), are not exported to B's closest more capital-abundant trading partner, country C. In this case, however, the goods do go to both more capital-abundant and less capital-abundant countries, A and D.

In sum, something like the intuitive trade pattern is emerging here. On the one hand there are countries, like D in its trade with B, and A in its trade with C, that import all that a country has to offer on world markets. But there are also countries, more similar to the exporting country in terms of factor endowments, that import only those of its exports which they are least suited to producing themselves. In trade with these countries it seems clear that one finds the intuitive pattern of bilateral trade.

Before leaving this model I should acknowledge that some aspects of the trade pattern in Figure 3 may not arise for other configurations of factor prices and costs. First, if a country were small enough it might not export anything at all to its closest neighbors on the factor abundance ranking. For example if a small additional country were inserted into Figure 3 with factor prices intermediate between those of B and C, it would export a small group of goods near \(z_5\) to both A and D, and nothing at all to B and C. Thus its trade would again look like the neutral
case of Figure 1, in spite of transport costs. Second, the impression given in Figure 3 that countries tend to export the larger part of what they produce need not be true at all. Again a small country will tend to produce a much larger range of goods than it exports, even when transport costs are small.

3. Counter-intuitive Trade Due to Differences in Demand

It is tempting to conclude from the analysis just completed that bilateral trade must conform to the intuitive pattern described by Krueger, or at worst be neutral if countries do not trade at all with those that are most similar to themselves in terms of factor abundance. After all, trade impediments are a fact of life and should normally suffice to generate patterns of specialization something like those in Figure 3. But in fact, even in Figure 3, the intuitive pattern of trade is not assured. The price relationships shown there are enough to determine what will be produced and traded, but not how much. For the latter the demands for goods must be considered. As long as the groups of goods a country exports in two directions include at least two goods in common, then differences in demands in the importing country can lead to a counterintuitive pattern of bilateral trade.

This is most easily seen when the structure of preferences is simply different in the two importing countries. Consider for example the case of the neutral trade pattern generated in Figure 1 when country B was relatively large and A and C had endowment rays OA' and OC' respectively. Suppose that preferences were to differ internationally, so that, at identical prices, C prefers a higher ratio of $X_3$ to $X_2$ than does A. Then since these demands are satisfied entirely from B, B will export a higher ratio $X_3/X_2$ to C than to A. This is just the opposite of the intuitive pattern of trade.

Nor must preferences be different in order to generate this result. If preferences are
identical but incomes and income elasticities of demand differ appropriately, the same result can be constructed. Just let $X_3$ be more income elastic than $X_2$ and let incomes be higher in C than in A. Then, again, B will export a higher ratio, $X_3/X_2$, to C than to A.

These two examples are theoretically valid. On the other hand, they are precisely those that trade theorists often rule out in other contexts by assuming identical homothetic preferences. With free trade it does appear that this latter assumption is sufficient to rule out the counterintuitive pattern of trade. In the H-O continuum model, then, free trade and identical homothetic preferences assure that the bilateral pattern of trade will be perfectly neutral.

With impeded trade, however, this assumption about demand does not help. Even with identical and homothetic preferences, the price differences that transport costs themselves induce would normally cause demands to differ internationally. These differences in demand may then lead to a counterintuitive pattern of trade.

To see how this can happen, consider the case pictured in Figure 4 and suppose that initially identical demands are then altered by modifying prices to include transport costs. The situation shown is one in which country A produces only $X_1$, B produces $X_2$ and $X_3$, and C produces $X_4$. The solid isoquants shown are unit-value isoquants corresponding to the prices prevailing in each exporting country. As drawn there is some room in each country for the prices of imports to rise without their becoming profitable to produce domestically.

Suppose then that a small and constant-percentage transport cost is added to the price of each good in importing countries. This is indicated in the figure by the inward shift of each of the unit-value isoquants to reflect their higher c.i.f. prices. Now consider the quantities demanded of goods $X_2$ and $X_3$ in countries A and C. Since these two goods are produced only in B, these demands are also their imports from B. Suppose that relative demands would have been identical in
Figure 4
the two countries had they both faced the same prices. In country A the prices of goods $X_2$, $X_3$, and $X_4$ have all gone up by the percentage transport cost, which means that the relative price of good $X_1$ has fallen. By the same token, in country C the relative price of good $X_4$ has fallen. How the two countries' relative demands for $X_2$ and $X_3$ now compare, therefore, depends on complementarities and substitutabilities between $X_1$, $X_4$ and the other goods.

Suppose that $X_1$ and $X_2$ are complements, and that $X_3$ and $X_4$ are also complements. Then the fall in relative price of $X_1$ in A will increase A's relative demand for $X_2$, while the fall in relative price of $X_4$ in C will increase C's relative demand for $X_3$. Thus transport costs and complementarities cause the same difference in relative demands here that resulted earlier in this section from assumed differences in preferences or income elasticities. As before, the result is the counterintuitive trade pattern where B exports a higher ratio of $X_3/X_2$ to C than to A.

Incidentally, this case can be strengthened to provide a much more dramatic example of counterintuitive trade. Suppose that preferences everywhere are such that $X_1$ and $X_2$ are perfect complements so that they must be consumed in fixed proportions, that $X_3$ and $X_4$ are likewise perfect complements, and that an appropriate bundle of $X_1$ and $X_2$ substitutes perfectly for an appropriate bundle of $X_3$ and $X_4$. Suppose further that at the prices underlying the solid unit-value isoquants in Figure 4, consumers are indifferent between the two bundles. Then in countries A and C, since transport costs raise the prices of both goods in one bundle but only one in the other, demands will fall to zero for both goods in the more expensive bundle. The result is that A consumes only $X_1$ and $X_2$, importing only $X_2$ from B. C consumes only $X_3$ and $X_4$, importing only $X_3$ from B. Country B therefore exports only (capital intensive) $X_3$ to (capital abundant) C and (labor intensive) $X_2$ to (labor abundant) A. The pattern of B's bilateral trade is counterintuitive in the
extreme.

These examples leave open the question of whether any plausible assumption can be made about preferences that will assure the intuitive pattern of trade. In the continuum model with constant across-the-board transport costs that appeared in Figure 3, it is sufficient as already noted if identical preferences require consumption of all goods in fixed proportions regardless of prices. More generally, it will also be sufficient if relative demands for any pair of goods depend only on their own relative prices, independently of prices of other goods. For then all common exports of a country to two different destinations will be in the same proportions, since both foreign markets will face the same prices for the exported goods. This property in turn will hold if and only if utility can be expressed as a constant elasticity of substitution (CES) function. Thus if preferences are identical and CES or, of course, Cobb-Douglas as assumed by DFS, then the continuum model of section 2 with transport costs must yield the intuitive pattern of bilateral trade.

It is interesting that such a strong assumption about preferences is needed to give a clear result. Demand conditions have typically not been of primary interest in generating the results of trade theory, although Jones (1980) has reviewed a number of problems for which demand conditions do matter crucially. Also, the apparent need to rule out complementarities in demand, as is done when preferences are assumed to be CES, has come up in the slightly different context of the tendency toward factor price equalization in Deardorff (1983a). This suggests that complementarities in demand, and the need to rule them out by making stronger-than-usual assumptions about preferences, may become increasingly important in trade theory as it is extended to models with a large number of goods.
4. Country-Dependent Transport Costs

In the analysis so far, transport costs, when they have appeared, have always been the same for all goods and the same for a given good regardless of the origin and destination of the good in trade. These are bad assumptions for several reasons. Most obviously, transport costs between different pairs of real world countries are not the same in fact. There are large differences in distances between countries. Also, differences in geography separate some countries by water, some by mountains, and some by nothing more than a fence. These varying geographical barriers cause substantial transport costs for some goods, but not others.

More important than actual transport costs, however, may be other institutional and cultural barriers. These also impede trade in many goods, and the abstract modeling of transport costs may be expected to encompass them. Thus tariffs and other deliberately imposed nontariff barriers commonly depart from the Most-Favored-Nation principle. There are tariff preferences, free trade areas, and a host of quantitative import restrictions that are allocated unevenly across foreign exporters. In addition, as U. S. exporters to Japan are fond of reporting and as many others who have tried to penetrate foreign markets have surely learned, cultural differences between countries provide a different kind of trade impediment that seems sometimes almost insurmountable.

For many purposes these differences in trade barriers may not be important. It is

12. The models of this section had been constructed and the first draft of this paper had been written before I learned of their similarity to certain well-known science fiction novels. My colleague Hal Varian pointed out the similarity of my first model, which I had called a "River World," to Philip Jose Farmer's "Riverworld," the subject of a series of novels beginning with Farmer (1971). I asked him then whether science fiction might also offer a more imaginative name for my last model, which I was calling "A Two-Tier Model." To my further surprise, he told me of another series of novels by the same author dealing with the "World of Tiers." The first in that series is Farmer (1965). I have renamed my models here, though only slightly, to reflect their literary antecedents. I have yet to decide whether this coincidence should be acknowledged with apology or with pride.

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understandable that most trade models, with the notable exception of the theory of customs unions, have not taken them into account. However it seems likely that a good deal of bilateral trade among some countries, and its absence among others, is best explained in terms of differences in such trade barriers. Thus a study such as this of the direction of bilateral trade would be ill advised to ignore the phenomenon entirely.

There is a final reason for considering country-dependent differences in transport costs, and it is also suggestive of the particular pattern that transport costs often take and that I will use to motivate the models considered below. It has long been observed that a disproportionate amount of trade takes place among countries of similar levels of development. This pattern accords poorly with the Heckscher-Ohlin model which, as the models of this paper have already implicitly suggested, generates the greatest trade between countries of widely different factor endowments. This seeming contradiction led Linder (1961) to formulate an alternative hypothesis about the determinants of trade. He focused more on similarities in demand than on differences in supply. Attempts to test Linder’s hypothesis empirically, however, have been made difficult by the cross-section collinearity between transport costs and differences in per capita incomes. That is, countries with similar per capita incomes—which should according to Linder trade heavily with one another due to similarities in demand—also tend to be close together geographically. Once distance is included as an explanatory variable in a regression explaining bilateral trade, it is difficult to find an independent role for per capita income.

That this collinearity exists is obvious from casual observation. Whatever the reason, a

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13. This is exactly what happens, for example, in Figure 3, where each country exports a larger range of goods to that country most unlike itself than to those most like itself in terms of factor endowments.

14. See Deardorff (1983b) for a discussion of the empirical literature attempting to test the Linder hypothesis.
large number of the most developed countries are located in Europe. If one adds to this the likelihood that cultural and often even institutional barriers to trade are also lowest among countries of similar levels of development, the case for a particular form of transport cost variation becomes quite strong. That is, I will look at models in which transport costs tend to be lowest between countries with similar factor endowments.

To make the models manageable and their implications starkly clear, I will allow transport costs to take only the extreme forms of being either zero or prohibitive for particular goods between particular pairs of countries. This still leaves considerable scope for variety in setting up models in which transport costs play different roles.

4.1 The Riverworld with Re-exports

Suppose that the countries of the world are arranged along a river and surrounded otherwise by jungle. As suggested by this arrangement, I will assume that costs of transporting goods are zero between any adjacent pair of countries along the river but infinite for trade directly between countries that are not adjacent. To capture the observation above that transport costs tend to be lower between countries of similar endowments, I will for now arrange the countries along the river in the order of capital abundance. This is shown in Figure 5 where, as before in this paper, capital abundance is least in country A and greatest in country D. For ease of exposition I will have the current of the river flow from right to left, so that I can speak of the most developed, capital-abundant country D as being "upstream" of the others. 15

With these assumptions about transport costs, trade will still equalize the prices of all goods in different countries, so long as all countries are free to re-export. That is, I will assume

15. The direction of the current plays no real role in this model, since transport costs are zero in both directions. It might be intriguing to examine a variant of the model where this was not true, though it is not obvious what the significance of such a model would be.
Least Capital-Abundant

Most Capital-Abundant

Figure 5
for the moment that it is costless for each country to export to one neighbor what it has imported from the other. Then, in effect, each country can trade freely with every other country, so long as trade between non-adjacent countries passes through the countries that lie between them.

The pattern of net trade will therefore be exactly what it is in any other model with free trade. But the pattern of (gross) exports will be quite different, since it will include all of the goods that only pass through the country on the way to being re-exported to another.

As an example of what happens, suppose that the four countries in Figure 5 are the same ones met earlier in Figure 2, where with free trade each country specializes in a contiguous group of goods along a continuum of factor intensities. In a Riverworld these countries produce as before, but their trade now includes re-exports. Trade is shown for each good and pair of countries along the river by the arrows in Figure 5. Goods $X_1$, for example, are produced entirely in country A. A's entire exports of $X_1$ go directly to country B, which keeps some to consume and re-exports the rest upstream to C, and so on.

Now look at the bilateral trade pattern of a midstream country like B. It produces only goods $X_2$, and exports them in both directions, to A and C. But, at the same time, B also exports the more labor intensive goods $X_1$ to its more capital-abundant neighbor, C, and the more capital-intensive goods $X_3$ and $X_4$ to its more labor-abundant neighbor, A. Thus bilateral exports in this model conform very strongly to the intuitive pattern of trade.

It seems to be true in general that bilateral trade in a river world will be intuitive, so long as countries are arranged along the river in the order of their capital abundance. Certainly more countries could be added without interfering with the result. And indeed it is easily seen that the same sort of pattern holds even if factor prices are equalized internationally. As usual in such a case, the pattern of trade in goods is indeterminant, but the factor content of bilateral exports
will follow the intuitive pattern. That is, the capital-labor ratio embodied in upstream exports will be smaller than the capital-labor ratio embodied in downstream exports.\textsuperscript{16}

The arrangement of the countries geographically does however seem to be crucial. To see this consider the following example that gives rise to a largely counterintuitive pattern of exports. Suppose there are many countries, A, B, ..., Z, ordered alphabetically by capital abundance. Suppose too that there are only two goods, $X_1$ and $X_2$, and that in a free trade equilibrium there is complete specialization everywhere with countries A, ..., M producing labor intensive $X_1$ and N, ..., Z producing $X_2$. If the countries occupy a Riverworld with the special geographical arrangement shown in Figure 6, then the following odd pattern of trade emerges: With the exception of countries M and N (which export only one direction) and A and Z (which are at the extremes in terms of factor abundance), all countries export the more capital intensive good $X_2$ to their more capital-abundant neighbor, and \textit{vice versa}. Thus for all countries for which the intuitive pattern of trade is possible, exactly the opposite counterintuitive pattern of trade occurs.

\textbf{4.2 The Riverworld Without Re-exports}

One might object, in the models just considered, to the fact that most of the trade consists of re-exports. It is interesting therefore to see what would happen in a Riverworld if re-exports were not allowed. Such a prohibition might be institutional, though it might also arise naturally, admittedly in a very special case. Suppose that while transportation on the river is costless in physical terms, it does take time, and suppose also that goods are perishable. If goods survive long enough to get from one country to the next along the river and be consumed, but never long

\begin{itemize}
\item[16] Actually, extreme differences in demand of the sort discussed in section 3 could interfere with this result even here.
\end{itemize}
Figure 6

Net Exporters of $X_1$  

Least Capital-Abundant

Net Exporters of $X_2$

Most Capital-Abundant

$X_1$  

$X_2$
enough to last through a second trip, then exports to neighboring countries will be free while re-exports will be impossible.

Such a model is complicated because, of course, prices need no longer be equalized between countries. Worse still, imports can be cheaper than domestically produced goods of the same kind, so long as the latter can all be sold abroad in a market that the imports, without being re-exported, cannot reach. Thus there is not even a single set of relative prices within a country, but instead separate prices for domestic goods and for imports from different sources.

To make the model manageable, therefore, I will look at it in a particularly simple form. Suppose there are three countries producing two goods. Countries A and C, being separated on the river by B, can trade freely with B but not at all with each other. Let A and C be both extremely large compared to B, so that they behave essentially as closed economies. B can therefore take their autarky prices both as exogenously given terms on which it can trade. It is then possible to analyze the behavior of country B.

In Figure 7, TT' is the transformation curve of country B. Relative prices in country A are given, for example, by the slope of the line P_1C_0, while relative prices in country C are given by the slope of P_3C_4. These prices differ, the relative price of labor-intensive X_1 being lower in labor-abundant country A. Residents of B can take advantage of this difference to an extent, but they cannot arbitrage the price difference away, since they are unable to re-export to country C the X_1 they have imported from country A. Instead they are limited to exporting, of either good, only what they themselves produce.

One alternative consists of producing at P_2. By exporting the entire output of X_2 to A in exchange for X_1, and also exporting the entire output of X_1 to C in exchange for X_2, country B can acquire the bundle of (imported) goods at C_2. Geometrically, C_2 is constructed by drawing a
parallelogram with corners at \( P_2 \) and on both axes, and with sides whose slopes are the relative prices in A and C. The fourth corner of the parallelogram then gives a feasible point of consumption.

By repeating this construction for other points on the transformation curve, the complete consumption possibility curve of country B is traced out: \( C_0C_1C_2C_3C_4 \). It includes a curved portion between \( C_1 \) and \( C_3 \) where all domestic production is exported. It also includes two straight segments, \( C_0C_1 \) and \( C_3C_4 \), along which part of the output of one of the goods, \( X_1 \) and \( X_2 \) respectively, is retained for consumption.

For example, if consumer preference for \( X_1 \) is high, equilibrium may be found at point \( g \). To get there, production must occur at \( P_1 \), with all of the output of \( X_2 \) exported and only a fraction (it looks like about two-thirds) of the output of \( X_1 \) exported. In this situation the domestic price of \( X_1 \) must equal its price imported from A. Since domestic \( X_2 \) is also exported to A, the relative price of domestic \( X_1 \) to domestic \( X_2 \) must equal the price ratio in A. That in fact is what induces production at \( P_1 \), where \( TT' \) has slope \( P^A \). Consumers, on the other hand, do not consume domestic \( X_2 \) but import it more cheaply from C. Thus consumer prices are those in country C, which by construction is also the slope of \( C_0C_1 \). Alternatively, if all domestic output is exported, as in attaining \( C_2 \), then neither producer nor consumer prices will equal either foreign price ratio, and they may differ in either direction from each other as well.

Notice, now, the pattern of trade, which is the same for all possible equilibria in \( C_0C_4 \). Country B imports both goods from the countries where they are relatively cheapest. To pay for these imports, B must therefore export in return different goods to each. This in turn means
exporting labor intensive goods to the more capital-abundant country and vice versa. Thus trade once again follows the intuitive pattern.

This model has a number of odd and interesting features, many of which I am sure are evident by now. One that may not be evident is the following: If, starting from a point like $C_2$, consumers' preferences in B change in favor of consuming more, say, of good $X_1$, then production of good $X_1$ in B will actually fall. This seemingly perverse result stems from the fact that $X_1$ is not produced for consumption at all, but only for trade with country C in exchange for $X_2$. When demand for $X_2$ falls, the need for $X_1$ to use in trade also falls.

4.3 A World of Tiers

So far I have kept transport costs the same for all goods. By relaxing this assumption in a particular way, I obtain what I believe is a quite attractive model of trade both between and within blocks of countries. I call it a world of tiers. The tiers are groups of countries and the model is characterized by the fact that, while some goods are freely tradable world-wide, others are tradable only within tiers. Thus there is now a subset of the world's goods for which trade barriers vary by country.

I will again look only at a simple version of this model, which suffices to illustrate its properties. There are four countries, three goods and two tiers. Countries A and B form one tier while C and D form the other. In line with my earlier comments about trade barriers being lowest among similar countries, I will assume that countries C and D are both more capital abundant than A and B.

Goods $X_1$ and $X_2$ are freely tradable worldwide. I will assume that demands for both are so large compared to demand for $X_3$ that any resources that will be devoted to producing $X_3$ will be
negligible compared to those resources producing $X_1$ or $X_2$. This "small industry" assumption enables me to fix the world equilibrium solely on the basis of $X_1$ and $X_2$ alone, and to add $X_3$ later once factor prices everywhere are given.

In terms of $X_1$ and $X_2$, then, let the equilibrium be described by the solid curves in Figure 8. The $X_1$ and $X_2$ unit-value isoquants are shown and are common to all countries since these goods are traded freely. Factor prices are, as usual, assumed to be different in each country, as shown. Countries A and B produce $X_1$, while countries C and D produce $X_2$. Endowment ratios of the countries would be given by slopes of rays, not shown, from the origin through points a, b, c, and d respectively. The pattern of bilateral trade in these two goods is only partially determinate. A and B export $X_1$ to C and D, but one cannot tell which exports to which or whether both export to both.

Now add a third good, $X_3$, which is to be freely traded only within tiers. It will in general have two different prices in the two tiers, and there will therefore need to be two different unit value isoquants to describe its production. These isoquants must, as always, be tangent to the outermost of the unit isocost lines of the countries to which they apply. What happens exactly depends on the factor intensity of $X_3$.

In the case drawn in Figure 8, $X_3$ is intermediate in capital intensity between $X_1$ and $X_2$. As a result, the relevant unit-value isoquants are those shown, tangent to the $v^B$ and $v^C$ factor price lines.\textsuperscript{17} Thus good $X_3$ is produced only in countries B and C, and is exported by each to its partner.

\textsuperscript{17} As drawn, $X_3$ is also priced higher in A and B than in C and D. This would be reversed if $X_3$ were somewhat less capital-intensive.
in the same tier.

Looking at the bilateral pattern of trade, the intuitive result again appears. Country B, for example, exports a more capital-intensive good, $X_2$, to its less capital-abundant partner, A, while exporting a more labor-intensive good, $X_1$, to C and/or D. A similar pattern holds for country C, which exports $X_3$ to D and $X_2$ to A and/or B. The pattern does not hold, of course, for countries A and D, but these both export only one good and in one direction.

If $X_3$ were of more extreme factor intensity, this pattern of trade would be altered in one, but not both, of the tiers. As the reader can verify, if $X_3$ were more capital-intensive than $X_2$, it would be produced in country D rather than country C. Country B’s trade pattern would be the same as described above. However C would now export only $X_2$, while D would simultaneously export $X_3$ to C and $X_2$ to A and/or B. D’s trade pattern here might be termed "weakly counterintuitive." While it exports only to less capital-abundant countries than itself, among those countries the capital intensity of its exports is positively correlated with their capital abundance.

The World of Tiers model suggests a generalization of the factor proportions theory of trade that perhaps deserves further study. It says that trade between groups of countries reflects the factor endowments of the groups and of the countries relative to the world. Trade within groups, on the other hand, reflects the factor endowments of the countries only relative to other countries in the same group.

5. Conclusion

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18. Depending on how international payments are organized in this world, D will either run a bilateral trade surplus with C, or will import a small amount of $X_2$ from C for reexport to A and/or B.
I have looked in this paper at the determinants of bilateral trade patterns for countries at various levels of development in terms of their factor endowments. It has been observed empirically that countries' exports to less-developed countries tend to be more capital-intensive than their exports to more-developed countries. I wished to determine whether this "intuitive" pattern of trade could be explained in terms of the familiar pure theory of international trade. For this purpose I examined a variety of specific variants of the Heckscher-Ohlin trade model. The specific models all had two factors of production and internationally unequal factor prices. They differed, however, in terms of the numbers of goods and countries that were included, as well as the extent to which differences in demand and transport costs could condition the bilateral pattern of trade.

The result of this exploration of trade models is that the intuitive pattern of trade can indeed be explained in terms of Heckscher-Ohlin trade theory. However it is by no means inevitable, since several examples of counterintuitive trade patterns also appeared. While some of these counterexamples require what I believe are implausible assumptions (e.g., Figure 6), one of them (examined in Figure 4) requires no more than the existence of transport costs and certain complementarities in demand. Thus I have not been able to show that the intuitive pattern of trade must arise under any usefully general assumptions.

On the other hand, I also found enough cases where the intuitive pattern does occur to make the Heckscher-Ohlin model a natural vehicle for explaining it. Thus differences in demand aside, the continuum-of-commodities version of the Heckscher-Ohlin model led, in the presence of uniform transport costs, to the intuitive pattern of trade quite naturally.

Finally, I pursued the matter further, into the realm of models where trade impediments differ across countries and commodities. Here again, in several stylized models of trade and transport costs, I found the intuitive pattern of trade emerging easily. With the added assumption that trade barriers are lowest between similar countries, these models have the advantage of
explaining intuitive patterns of trade among countries that need not differ greatly in their levels of development.

I conclude that while the traditional two-dimensional Heckscher-Ohlin trade model is, by its size, inadequate for problems of this sort, its generalization to include more goods and countries together with barriers to international trade is quite useful in explaining developing countries' trade.

As to what it is that gives rise to the particular intuitive pattern of bilateral trade that has been observed, I have no unambiguous conclusions to offer. However, while neither necessary nor sufficient for its occurrence, barriers to trade such as transport costs do seem to be of primary importance in explaining the intuitive bilateral pattern of trade. More than that, it appears that the intuitive trade pattern is most likely to arise when trade barriers exist but are smallest between countries of similar factor endowments.
REFERENCES


_________ (1983a) "An Example of International Factor-Price Divergence," in process (Mar.)


Samuelson, Paul A. (1954) "The Transfer Problem and Transport Costs, II: Analysis of Effects of