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The Directions of Developing-Country Trade: Examples of Pure Theory*

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Many developing countries – defined, perhaps optimistically, as those countries 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, they tend to export their more capital-intensive goods to countries that are less abundantly endowed with capital than themselves, while exporting their less capital-intensive goods to more capital-abundant countries.[1] This intuitively plausible pattern of trade is not found in most of the pure theory of international trade, which typically deals with a world of only two countries. Even recent contributions that deal with many 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, for example, looked at bilateral trade only to compare the characteristics of a country's exports to and imports from a single trading partner; he did not compare exports to different trading partners.[3] A good understanding of whether the standard models of modern trade theory either permit or require this intuitive pattern of bilateral trade is therefore lacking. The purpose of this paper is to contribute to that understanding.

As it turns out, it cannot be shown with any generality that the intuitive pattern of trade *must* arise in trade models. Indeed, several examples suggest just the opposite: a counterintuitive pattern of bilateral trade. In most of the more plausible cases, however, the intuitive trade pattern does arise. This paper analyzes a number of specific trade models, some of which illustrate the plausibility of the intuitive result, others the

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[1] An early observation of this pattern of bilateral trade was found for Japan by Tatemoto and Ichimura and reaffirmed by Heller. See Masahiro Tatemoto and Shinichi Ichimura, "Factor Proportions and Foreign Trade," *Review of Economics and Statistics,* vol. 41 (November 1959), pp. 442-46; and Peter S. Heller, "Factor Endowment Change and Comparative Advantage: The Case of Japan, 1956-1969," *Review of Economics and Statistics,* vol. 58 (August 1976), pp. 283-92. Evidence for India can be found in Khanna, which also includes references to other work on this subject. See Ashok Khanna, *Testing for the Direction of Exports,* World Bank Staff Working Paper 538 (Washington, D.C., 1982).

[2] See, for example, Ronald W. Jones, "The Small Country in a Multi-Commodity World," *Australian Economic Papers,* vol. 13 (1974), pp. 225-36, reprinted as chapter 2 in Ronald W. Jones, *International Trade: Essays in Theory* (Amsterdam: North-Holland, 1979); Anne O. Krueger, *Growth, Distortions, and Patterns of Trade among Many Countries,* Princeton Studies in International Finance 40 (Princeton; N.J.: Princeton University, Department of Economics, International Finance Section, 1977); and Alan V. Deardorff, "Weak Links in .the Chain of Comparative Advantage," *Journal of International Economics,* vol. 9 (March 1979), pp. 197-209.

[3] R. Spence Hilton, "An Estimatable Model of the Commodity Version of Trade," Ph.D. dissertation, University of Wisconsin, Madison, 1981.

possibility of its opposite, to draw attention to those features of the world economy that may account for the frequency with which the intuitive trade pattern is observed.

It is useful at the outset to explain how the term "intuitive" is used and why this "intuition" does not provide a sufficient explanation for patterns of trade. Trade derives from comparative advantage. In. turn, comparative advantage derives, in a Heckscher-Ohlin framework, from relative factor endowments and relative factor intensities of traded goods. It is plausible- and correct in theory-that a country able to produce goods with different factor intensities will have a greater comparative advantage in the more capital-intensive of those goods (measured by differences in relative autarky prices) than countries less developed than itself. Thus, the country might be expected to export relatively more of these goods to the less developed countries, while exporting more of its more labor-intensive products to more developed countries. This pattern would presumably occur if the extent of trade, and not just its direction, were positively related to the size of comparative advantage.

For a variety of reasons, the standard models of trade such as Heckscher-Ohlin do not imply a Quantitative relationship between trade and comparative advantage.[4] The reasons include both the general equilibrium effects of trade on factor prices-which tend to remove the very cost differences that give rise to trade-and the elasticity of supply functions-which, if sufficiently elastic, may mean the Quantities traded depend more on demand than on supply. Therefore; although the observed pattern of trade can be explained intuitively by comparative advantage, a more careful explanation must focus on how supplies and demand interact on
trade.

Krueger has addressed this issue in theoretical terms, though only as a byproduct of her analysis of patterns of specialization. In a Heckscher-Ohlin model with many goods and countries, two factors, and internationally unequal factor prices, Krueger states, "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."[5] Krueger 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.”[6] Thus, she finds transport costs to be crucial in determining the bilateral pattern of trade and implying the intuitive result. Khanna expands somewhat on Krueger's theoretical analysis, explaining her conclusions more fully.[7] (The examples of trade patterns Khanna uses are essentially the same as those discussed later.)

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[4] For more discussion of this point, see Alan V. Deardorff, "Testing Trade Theories and Predicting Trade Flows," chapter 10 in Ronald W. Jones and Peter B. Kenen, eds., *Handbook of International Economics,* vol. I: *International Trade Theory* (Amsterdam: North-Holland, 1984). This lack of a quantitative relationship has induced some investigators, beginning with Harkness and Kyle, to use binary-variable econometric techniques for empirical applications of the theory. See Jon Harkness and John F. Kyle, "Factors Influencing United States Comparative Advantage," *Journal of International Economics,* vol. 5 (May 1978), pp. 153-65.

[5] Krueger, *Growth, Distortions, and Patterns of Trade,* p.21.

[6] Ibid.

[7] Ashok Khanna, "Testing for Directionality of Trade: India's Exports of Manufactures in the 1970's," Ph.D. dissertation, Stanford University, 1982.

Here it will be shown that the existence of transport costs is neither necessary nor sufficient for explaining the intuitive pattern of trade, even though the structure of transport costs does provide the most insight into the observed pattern of trade. The balance of the introduction shows, through a simple and familiar example, how the intuitive pattern of trade might arise with free trade, but also how each country might as easily be exporting the same bundle of goods to all foreign markets. In the next section, the likelihood of these two outcomes is assessed using a multicountry extension of Dornbusch, Fischer, and Samuelson's version of the Heckscher-Ohlin model with a continuum of goods,[8] With this model, which has free trade and unequal factor prices, it is shown that the same goods are exported to all countries. When transport costs are introduced, however, something like the intuitive trade pattern emerges. In this case, the model readily implies that countries will export a range of more capital-intensive goods to less capital-abundant neighbors and vice versa.

The section thereafter returns to a model with a discrete number of goods to show how differences in demand can give rise to counterintuitive patterns of trade. That is, countries in some circumstances may export their more capital-intensive goods to countries that are more, rather than less, capital-abundant than themselves, Since these differences in demand could arise from the price differences caused by transport costs, such costs are clearly not a compelling reason for the intuitive pattern of trade.
Greater insight into bilateral trade may come from taking into account the differences in transport costs among the various trading partners of a particular country, and perhaps among the various goods it trades. To this end, the following section examines models that allow such differences in the extreme cases where bilateral transport costs are either zero or prohibitive. Depending on the pattern of these transport costs, both intuitive and counterintuitive trade patterns may emerge, although the cases that correspond best to the real world do follow the intuitive pattern. Indeed, the last of the models – called here a World of Tiers – is a plausible yet simple model of trade both between and within the North and South, and it readily implies the observed intuitive pattern of their trade.

Several assumptions are made in all the examples in this chapter. First, the number of factors of production is always two-capital and labor. Although more factors must be considered to explain trade fully, the two-factor assumption focuses attention most precisely on the issue of bilateral trade that is addressed here. It is also possible, as Krueger has done, to augment any of these models by adding other factors, together with other sectors to which these factors, rather than capital, are specific.[9] The results would still apply for the sectors that employ capital and thus may be said to refer to that portion of trade involving manufactured goods.

A second assumption that pertains throughout is that factor prices are not equalized across countries. Krueger argues that this is a natural assumption when dealing with countries at vastly different levels of development.[10] The assumption 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, some

[8] Rudiger Dornbusch, Stanley Fischer, and Paul A. Samuelson, "Heckscher-Ohlin Trade Theory with a Continuum of Goods," *Quarterly Journal of Economics,* vol. 95 (September 1980), pp. 207-24.
[9] Krueger, *Growth, Distortions, and Patterns of Trade.*
[10] Ibid.

of the countries considered here may represent groups of countries with endowments so similar that there is equalization of factor prices within groups.

Finally, the usual assumptions of Heckscher-Ohlin trade theory are used throughout. 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.[11])

To begin the analysis, consider figure 2-1, which illustrates a possible configuration of unit-value isoquants with unit-isocost lines for three countries (with capital intensity rising from country *A* to *C*), four goods (X_1 to X_4), and two factors (capital, *K,* and labor, *L*).[12] In this example, the free-trade world prices of the four goods, which determine the locations of the four isoquants, 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 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. The 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. 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, as shown in the first specialization matrix in figure 2-1. Assuming that countries import only goods that they do not export (more on an alternative assumption later), the pattern of exports of country *B* is precisely the intuitive pattern described earlier: it exports both goods X_2 and X_3, with the more capital-intensive good, X_3, going only to the less capital-abundant country, *A,* and the less capital-intensive good, X_2, going to the more capital-abundant country, *C*.

That the intuitive trade pattern need not arise can also be shown with figure 2-1. Suppose that the factor endowment ratios of the extreme countries *A* and C were even more extreme, as shown by the rays *OA′* and *OC′.* To make this feasible, *B* must be sufficiently larger than *A* and C to give rise to the intuitive trade pattern. With the same prices as before, countries *A* and C must now completely specialize in the 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. This pattern of specialization is shown in the second specialization matrix. Country *B,* as the only producer of X_2 and X_3, will now export both goods to both countries. Indeed, if the demand for the goods is identical, as is certainly possible, since the countries face identical prices in free trade, *B* will export X_2 and X_3 in the same proportions to both *A* and *C*; there will be no difference in the composition of *B*′s bilateral exports in the two

[11] Ronald W. Jones and J. Peter Neary, "The Positive Theory of International Trade," chapter 1 in Jones and Kenen, *Handbook of International Economics.*

[12] See Deardorff for more on the use of unit-value isoquants – the Lerner-Pearce Diagram – to illustrate trade equilibria with many goods and countries (Deardorff, "Weak Links"). 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: $X_1 = 1/P_1$, $X_2 = 1/P_2$, and so on. 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 the country produces.

directions. This pattern of trade is not the intuitive one found empirically, though it is not strictly counterintuitive, either. It is called here the neutral case.

Which of the two cases is more likely is difficult to say in a model with a discrete number of goods. As the examples suggest, much depends on the particular configurations of factor endowments, country sizes, and factor intensities. The picture becomes clearer, however, with the natural generalization of this model, in which there is a continuum of goods, as proposed by Dornbusch, Fischer, and Samuelson.[13]

The Heckscher-Ohlin Continuum Model

Assume, in keeping with Dornbusch, Fischer, and Samuelson, that the number of goods is infinite, indexed by z for all z on the unit interval (0,1).[14] Each good still has its own neoclassical, constant-returns-to-scale production function using inputs of capital and labor, and, in fact, its production can still be characterized by using unit-value isoquants. Given the factor prices, w and r, of labor and capital, respectively, the cost-minimizing labor and capital requirements per unit to produce good z depend on the ratio $v = w/r$:

$$a_L(z) = a_L(z; v)$$

$$a_K(z) = a_K(z; v)$$

Assume also that there are no reversals of factor intensity between any pair of goods and therefore that the ordering of the goods by z can also be their ordering by capital intensity. That is,

$$k(z; v) = a_K(z; v)/a_L(z; v)$$

is strictly increasing in z.

Dornbusch, Fischer, and Samuelson added explicit assumptions about demand in a model of this sort, with free trade and only two countries, and wrote out all of the conditions needed to determine a complete general equilibrium. The equilibrium is taken here as given and is characterized only as needed to determine the pattern of trade. The model here goes beyond Dornbusch, Fischer, and Samuelson, however, to consider more than two countries. In addition, two cases of the model-with free trade and with transport costs-are treated separately.

Free Trade

Given the factor prices that prevail at 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

$$c(z; w, r) = wa_L(z; w/r) + ra_K(z; w/r).$$

[13] Dornbusch, Fischer, and Samuelson, "Heckscher-Ohlin Trade Theory."
[14] Ibid.

With free trade, each country will produce only those goods for which its costs are at least as low as costs of production elsewhere. It is useful to graph these cost functions for several countries with different factor prices. The shapes of the graphs are arbitrary, since the units of measurement of the goods need not be comparable. For simplicity, they are drawn as straight lines, since linearity is possible in at least one special case[15] and since straight lines have one essential property that will be used to derive results-they cross, at most, only once. That the cost functions, whatever their shapes, must have this property is easily seen from the geometry of the unit-value isoquants and unit-isocost curves.[16]

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. Figure 2-2 shows this case 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,* becoming flatter as the wage rental ratios rise across the countries.[17]

With free trade, the pattern of specialization and trade is now obvious. As Krueger and Deardorff show for a discrete number of goods, each country specializes in a range of goods that are contiguous in their capital intensities.[18] 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.* (See the specialization matrix in figure 2-2.)

What is notable about this pattern of production is that virtually all goods are produced in only one country and are therefore exported by that country to all others. The expansion of the model to a continuum of goods virtually eliminates cases such as the first considered in figure 2-1. With free trade, each country exports the same range of goods to all other countries. The neutral pattern of bilateral trade shown in figure 2-1 is the only one that can arise in the continuum model with free trade, at least as long as demand for the goods is everywhere identical.[19]

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[15] Unit cost can be linear in z if the technologies are Leontief, so that $aL(Z; v) = aL(z)$ and $aKfz; v) = aKfz)$, both independently of v. If units of the goods are then chosen so that $aL(z) = 1$ for all z, and if K is linear in z, then $c(z) = w + rK(z)$ is also linear in z.

[16] To see this, suppose that a particular good, zo, costs the same at two different sets of factor prices. Then a single isoquant ofzo will be tangent to the unit-isocost lines for *both* sets of factor prices. The 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 the goods are more, or less, capital-intensive than zoo Drawing the cost curves as linear in z is a simple way of ensuring that they have this property and does not, as it turns out, influence any of the other results to be obtained here.

[17] This relationship is obvious in the Leontief technology case of note 15, since the flatter curves (lower *r)* also have a higher intercept (larger *w).* By pursuing the argument in note 16, the relationship can also be shown to be true in general.

[18] Krueger, *Growth, Distortions, and Patterns of Trade;* and Deardorff, "Weak Links."

[19] It may be suspected that the neutrality of the trade pattern here depends on the assumption that the products are homogeneous. To see that this is not the case, consider an Armington model in which all products are differentiated by j country of origin. Each country will produce all goods. See Paul S. Armington, "A Theory of Demand for Products Distinguished by Place of Production," *International Monetary Fund Staff Papers,* vol. 16, no. 1 (March 16, 1969), pp. ~ 159-78. With free trade and identical

Transport Costs

The continuum model is particularly well suited to incorporate a simple form of transport costs.[20] Suppose, following Samuelson, that transport costs are given by the "iceberg" model: a fraction of each good is used up in transport.[21] Here it is assumed that this fractional transport cost is the same for all goods and for all countries, whether they are the origin or destination of trade. Thus, a single number, *g,* between zero and one represents the fraction of any good that survives when it reaches its trade destination.

When this assumption is added to the model, a country will 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 cost of transport.

To see the pattern of specialization and trade in this situation, look at figure 2-3. It contains cost curves like those in figure 2-2,[22] together with the 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 goods that are never traded and countries that do not trade. Instead, as shown in the example, each country exports some goods and imports others, with all goods traded by somebody.[23] Unlike the free-trade case of figure 2-1, however, each country has a group of goods 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.

Consider, as an example, the goods in the group X_2 between z_1 and z_2. These goods are produced most cheaply in country *A,* as is evident from its cost curve, c_A, in relation to the others in that region. However, c_A does not lie below gc_B, meaning that *B* can get these goods more cheaply from its own domestic producers than 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.*

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 more labor-intensive of its exports – the group

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homothetic preferences, however, the pattern of trade will be neutral even with only a finite number of goods.

[20] See Dornbusch, Fischer, and Samuelson, 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. See Rudiger Dornbusch, Stanley Fischer, and Paul A. Samuelson, "Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods," *American Economic Review,* vol. 67 (December 1977), pp. 823-39.

[21] Paul A. Samuelson, "The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments," *Economic Journal,* vol. 64 (June 1954), pp. 264-89.

[22] This does not mean that transport costs could be changed without altering the equilibrium factor prices in various countries. The purpose, however, is not to derive equilibrium, but merely to characterize some aspects of it Therefore, 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 2-2.

[23] It is possible to get nontraded goods in this model; they turn out to be ones of intermediate factor intensity. A better model of nontraded goods would, however, surely rely on differences in transport costs across goods.

X_3 – go only to more capital-abundant countries. Its more labor-abundant trading partner, *A,* can compete effectively in these industries within its 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_5, are not exported to *B's* closest, more capital-abundant trading partner, *C*. In this case, however, the goods do go to both the more capital-abundant and less capital-abundant countries, *A* and *D.*

In sum, something like the intuitive trade pattern is emerging. On the one hand, there are countries, like *D* in its trade with *B* and *A* in its trade with C, that import all a country has to offer. There are also countries more similar to the exporting country in factor endowments that import only those of that country's exports which they are least suited to produce themselves. With these countries, bilateral trade clearly shows the intuitive pattern.

It must be acknowledged that some aspects of the trade pattern in figure 2-3 may not arise for other configurations of factor prices and costs. First, if a country were small, it might not export anything to its closest neighbors on the factor abundance ranking. For example, if a small country with factor prices between those of *B* and *C* were inserted into figure 2-3, 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 2-1, regardless of transport costs. Second, the impression given in figure 2-3 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 its exports, even when transport costs are small.

Counterintuitive Trade Resulting from 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 to the neutral pattern, in which countries do not trade with those most like themselves in factor abundance. After all, trade impediments are a fact of life and normally should suffice to generate patterns of specialization something like those in figure 2-3. In fact, however, even in figure 2-3, the intuitive pattern of trade is not ensured: the price relationships are enough to determine *what* will be produced and traded, but not *how much.* To determine the latter, the demand for goods must also be considered. As long as the groups of goods a country exports in two directions include at least two goods in common, differences in demand in the importing countries can lead to a counterintuitive pattern of bilateral trade.

This situation is seen most easily when the structure of preferences is different in two importing countries. Consider, for example, the case of the neutral trade pattern generated in figure 2-1, when country *B* was relatively large and *A* and C had endowment rays *OA'* and *OC',* respectively. Suppose that preferences differ internationally, so that, at identical prices, *C* prefers a higher ratio of X_3 to X_2 than *A* does. Given that these demands are satisfied entirely by *B, B* will export a higher X_3-X_2 ratio to *C* than to *A.* This situation 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 income and the income elasticities of demand differ, the result can be the same. Let X_3 be more income-elastic than X_2 and let income be higher in *C* than in *A.* Once again, *B* will export a higher X_3-X_2 ratio to *C* than to *A.*

Although these two examples are theoretically valid, they are precisely those that trade theorists often rule out in other contexts by assuming identical homothetic preferences. With free trade, this assumption seems sufficient to rule out the counterintuitive pattern of trade. In the Heckscher-Ohlin continuum model, then, free trade and identical homothetic preferences ensure that the bilateral pattern of trade will be perfectly neutral.

This assumption about demand does not work, however, with impeded trade. Even with identical and homothetic preferences, the price differences that transport costs induce normally cause demand to differ internationally, and the differences may lead to a counterintuitive pattern of trade. To see how this situation can happen, consider the case in figure 2-4, in which an initially identical demand is altered by modifying prices to include transport costs. 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 before domestic production becomes profitable.

Suppose a small and constant-percentage transport cost is added to the price of each good in the importing countries, indicated in the figure by the inward shift of each of the unit-value isoquants to reflect-their higher c.i.f. prices (including cost, insurance, and freight). Now consider the quantities of goods X_2 and X_3 demanded by countries *A* and *C.* Since only *B* produces these two goods, the demands are equal to *A's* and *C's* imports from *B.* Suppose that the relative demand would have been identical in 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 of the transport cost, which means that the relative price of good X_1 has fallen. In country *C,* the relative price of good X_4 has fallen. A comparison of the two countries' relative demand for X_2 and X_3 now depends, therefore, on the complementarity and substitutability between X_1 and X_4 and the other goods.

Suppose that X_1 and X_2 are complements, as are X_3 andX_4. Then the fall in the relative price of X_1 in *A* will increase *A's* relative demand for X_2, while the fall in the 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 as assumed differences in preferences or income elasticities brought about earlier in this section. As before, the result is the counterintuitive trade pattern, in which *B* exports a higher X_3-X_2 ratio 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 and 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 andX_4. Suppose, further, that at the prices underlying the solid unit-value isoquants in figure 2-4, consumers would be indifferent in their choice between the two bundles. Then, in countries *A* and *C*, since transport costs raise the prices of both goods in one bundle but of only one good in the

other, demand will then 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 $X2$ from *B.* Country *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 about preferences can be made to ensure the intuitive pattern of trade. That pattern is ensured in the continuum model with constant across-the-board transport costs (figure 2-3), if identical preferences require consumption of all goods in fixed proportions regardless of prices. More generally, it is also ensured if the relative demand for any pair of goods depends only on their relative prices, independent of the prices of other goods. 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 function of constant elasticity of substitution. Thus, if preferences are identical and the elasticity of substitution-or Cobb-Douglas production function, as assumed by Dornbusch, Fischer, and Samuelson-is constant, then the continuum model 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 has typically not been of primary interest in generating the results of trade theory, although Jones has reviewed a number of problems for which demand does matter crucially.[24] In addition, the apparent need to rule out complementarities in demand, as is done when preferences are assumed to have constant elasticity of substitution, has come up in the slightly different context of the tendency toward factor price equalization in Deardorff.[25] 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.

Country-Dependent Transport Costs

In the analysis so far, it has always been assumed that transport costs are the same for all goods and the same for a given good regardless of its origin and destination in trade. These assumptions are inappropriate for several reasons. First, transport costs between different pairs of countries are not the same in fact: the distances between countries may be large or small, and some countries are separated 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.

Second, and more important, institutional and cultural barriers also impede the trade of many goods. Because tariffs and other deliberately imposed nontariff barriers

[24] Ronald W. Jones, "Demand Behavior and the Theory of International Trade," in J. S. Chipman and C. P. Kindleberger, eds., *Flexible Exchange Rates and the Balance of Payments* (Amsterdam: North-Holland, 1980).

[25] Alan V. Deardorff, "An Example of International Factor-Price Divergence," University of Michigan, Ann Arbor.

commonly depart from the most-favored-nation principle, tariff preferences, free-trade areas, and a host of quantitative import restrictions are allocated unevenly among 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 are a different kind of trade impediment that sometimes seems insurmountable.

In many cases, these geographical, institutional, and cultural differences in trade barriers may not be important, and it is understandable that most trade models, with the notable exception of the theory of customs unions, have not taken them into account. It seems likely, however, that a good deal of bilateral trade among some countries and its absence among others is best explained by such differences. A study of the direction of bilateral trade is ill advised to ignore them entirely.

A final reason not to assume uniformity in transport costs motivates the models considered later[26] 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 chapter have already implicitly suggested, generates the greatest trade between countries of widely different factor endowments[27] This seeming contradiction led Linder to formulate an alternative hypothesis about the determinants of trade.[28] He focused more on similarities in demand than on differences in supply. Attempts to test Linder's hypothesis empirically have been complicated, however, by the cross-section collinearity between transport costs and differences in per capita income. That is, countries with similar per capita income – which should, according to Linder, trade heavily with one another because of similarities in demand – also tend to be close together geographically. When distance is included as an explanatory variable in a regression analysis of bilateral trade, it is difficult to find an independent role for per capita income.[29]

This collinearity is readily observed: whatever the reason, a large number of the most developed countries are located in Europe, for example. If to this is added the likelihood that cultural and often even institutional barriers to trade are lowest among countries of similar levels of development, the case for a particular form of transport cost variation becomes quite strong. Attention is paid in this section to models in which transport costs tend to be lowest between countries with similar factor endowments.

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[26] The models in this section had been constructed and the first draft of this paper written before their similarity to certain well-known science fiction novels became apparent. A colleague, Hal Varian, pointed out the similarity of the first model, called a "RiverWorld," to Philip Jose Farmer's "Riverworld," the subject of a series of novels, the first of which appeared in Philip Jose Farmer, *To Your Scattered Bodies Go* (New York: Putnam's, 1971). When the colleague was asked whether science fiction might offer a more imaginative name for the last model, called at the time "a two-tier model," he told me of another series of novels by the same author dealing with the 'World of Tiers," the first of which series appeared in Philip Jose Farmer, *The Maker of Universes* (New York: Ace, 1965). The models are renamed here, though only slightly, to reflect their literary antecedents. Whether this coincidence should be acknowledged with apology or with pride is as yet undecided.

[27] This is exactly what happens, for example, in figure 2-3, where each country exports a larger range of goods to that country most unlike itself than to those most like itself in factor endowments.

[28] Staffan Burenstam Linder, *An Essay on Trade and Transformation* (New York: Wiley, 1961).

[29] For a discussion on the empirical literature attempting to test the Linder hypothesis, see Deardorff, "Testing Trade Theories."

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

The Riverworld with Reexports

Suppose that the countries of the world are arranged along a river but are otherwise surrounded by jungle. In this Riverworld, the costs of transporting goods are zero between any adjacent pair of countries along the river but infinite for direct trade between countries that are not adjacent. To capture the observation above that transport costs tend to be lower between countries of similar endowments, initially the countries are arranged along the river in the order of capital abundance. This arrangement is shown in figure 2-5, with capital abundance least in country *A* and greatest in country *D.* For ease of exposition, the river flows from right to left, so that the most developed, capital-abundant country *D* is upstream from the others.[30]

Given these assumptions about transport costs, trade will equalize the prices of all goods in different countries, so long as all countries are free to reexport, that is, so long as it costs nothing for each country to export to one neighbor what it has imported from the other. In effect, each country can trade freely with every other country, so long as the trade between nonadjacent countries passes through the countries that lie in between. The pattern of net trade will therefore be exactly what it is in any other model with free trade. The pattern of gross exports, however, will be quite different, since it will include all of the goods that only pass through the country on the way to another.

Suppose, for example, that the four countries in figure 2-5 are the same ones met earlier in figure 2-2. 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 reexports. The arrows in figure 2-5 show the trade for each good and pair of countries along the river. Good X_1, for example, is produced entirely in country *A,* and all its exports of X_1 go directly to country *B.* Country *B,* in turn, consumes some and reexports the rest upstream to *C*, and so on.

Now look at the bilateral trade pattern of a midstream country like *B.* It produces only good X_2, exporting it in both directions to *A* and *C*. At the same time, *B* also exports the more labor-intensive good 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.

Bilateral trade in a Riverworld will generally be intuitive, so long as the countries are arranged along the river in order of their capital abundance. Certainly more countries could be added without interfering with the result. Indeed, it is easily seen that the same sort of pattern holds even if factor prices are equalized internationally. As is usual in such a case, the pattern of trade in goods is indeterminate, but the factor content of the bilateral exports will follow the intuitive pattern. That is, the capital-labor ratio embodied in

[30] The direction of the current plays no real role in this model, because transport costs are zero in both directions. It might be intriguing to examine a variant of the model in which that is not true, though it is not obvious what the model's significance would be.

upstream exports will be smaller than the capital-labor ratio embodied in downstream exports.[31]

The arrangement of the countries geographically seems to be crucial, however. To see this, consider the following example, which gives rise to a largely counterintuitive pattern of exports. Suppose there are many countries, *A, B, ..., Z,* ordered 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* through *M* producing labor-intensive X_1, and *N* through *Z* producing X_2. If the countries occupy a Riverworld with the special geographical arrangement shown in figure 2-6, then the following odd pattern of trade emerges. With the exception of countries *M* and *N* (which export in only one direction) and *A* and *Z* (which are at the extremes of factor abundance), all countries export the more capital-intensive good X_2 to their more capital-abundant neighbor, and vice versa. Thus, for all countries for which the intuitive pattern of trade is possible, exactly the opposite counterintuitive pattern of trade occurs.

The Riverworld without Reexports

One objection to the models just considered is that most of the trade consists of reexports. It is interesting to see what happens in a Riverworld if reexports are not allowed. Such a prohibition might be institutional, though it might also arise naturally, admittedly in a very special case. Suppose that the goods are perishable and that, although transportation on the river is costless in physical terms, it takes time. If the goods survive long enough to get from one country to the next along the river and to be consumed, but never long enough to last through a second trip, then exports to neighboring countries will be free in terms of transport but reexports 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 reexported, cannot reach. Thus, there is no 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, it is examined here 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* both be much larger than *B,* so that they behave essentially as closed economies. Country *B* can therefore take the autarky prices of both *A* and *B* as exogenously given terms on which it can trade. It is then possible to analyze the behavior of country *B.*

In figure 2-7, *TT′* is the transformation curve of country *B.* The relative prices in country *A* are given, for example, by the slope of the line P_1c_0, while the relative prices in country *C* are given by the slope of P_3c_4. These prices differ, with 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 reexport to country *C* the X_1 they have imported from

[31] Actually, extreme differences in demand of the sort discussed earlier could interfere with this result even here.

country *A.* Instead, they are limited to exporting only the amount of either good that 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: $c_0c_1c_2c_3c_4$. It includes a curved portion between c_1 and c_3 where all domestic production is exported, as well as two straight segments, c_0c_1 and c_3c_4, along which part of the output of one of the goods, X_1 andX_2, respectively, is retained for consumption. For example, if consumer preference for X_1 is high, the 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 some 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 imported price from *A.* Since domestic X_2 is also exported to *A,* the price of domestic X_1 in relation to domestic X_2 must equal the price ratio in *A*. That, in fact, is what induces production at P_1, where TT' has the slope P^A. Consumers, nonetheless, do not consume domestic X_2 but import it more cheaply from *C*. Thus, consumer prices are equal to 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 patterns of trade, which are 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 export 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. 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 of, say, 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 for trade also falls.

A World of Tiers

To this point transport costs have been kept the same for all goods. By relaxing this assumption in a particular way, it is possible to obtain an attractive model of trade between and within blocks of countries. It is called a World of Tiers: countries are grouped in tiers, some goods can be freely traded worldwide, and other goods can be traded only within tiers. Thus, for a subset of the world's goods, trade barriers exist and vary by country.

A simple version of this model is presented 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, with *C* and *D* the more capital-abundant. Goods X_1 and X_2 are freely tradable worldwide. Assume that the demand for both is so large, compared with the demand for X_3, that any resources devoted to producing X_3 will be negligible compared with those used to produce X_1 or X_2. This "small industry" assumption allows the world equilibrium to be fixed solely on the basis of X_1 and X_2, with X_3 added after factor prices everywhere are given. .

For X_1 and X_2, then, equilibrium is described by the solid curves in figure 2-8. 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. The endowment ratios of the countries would be given by the 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 can be determined only partially. Countries *A* and *B* export X_1 to *C* and *D,* but it is impossible to tell which exports to which or whether both export to both.

Now add a third good, X_3, which is freely traded only within tiers. It will, in general, have different prices in the two tiers, requiring 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 exactly happens depends on the factor intensity of X_3.

In figure 2-8, 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.[32] Thus, good X_3 is produced only in countries *B* and *C* and is exported by each to its partner in the same tier.

The intuitive pattern of bilateral trade 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* or *D.* A similar pattern holds for country *C*, which exports X_3 to *D* and X_2 to *A* or *B.* The pattern does not hold, of course, for countries *A* and *D,* but both export only one good and in only 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. Thus, 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* or *B.*[33] Country *D*'s trade pattern here might be termed "weakly counterintuitive": although 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 deserves further study. It says that trade between groups of countries reflects the factor endowments of the groups and of the individual countries relative to all countries. Trade within groups, in contrast, reflects the factor endowments of the individual countries relative only to other countries in the same group.

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[32] As drawn, X_3 is also priced higher in *A* and *B* than in *C* and *D.* This situation would be reversed if X_3 were somewhat less capital-intensive.

[33] 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* or *B.*

Conclusion

It has been observed empirically that the goods countries export to less developed countries tend to be more capital-intensive than those they export to more developed ones. The question is whether this intuitive pattern of trade can be explained by the familiar pure theory of international trade. To make this determination, a variety of specific variants of the Heckscher-Ohlin trade model were examined. The specific models all had two factors of production and internationally unequal factor prices. They differed, however, in the numbers of goods and countries that were included, as well as in the extent to which differences in demand and transport costs could affect the bilateral pattern of trade.

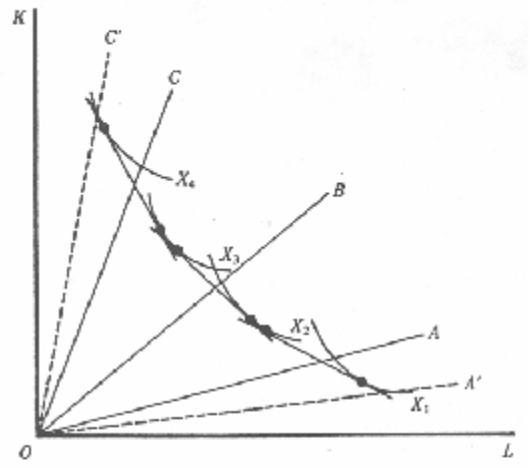
This exploration of trade models revealed that the intuitive pattern of trade could be explained by Heckscher-Ohlin trade theory. That pattern, however, was by no means inevitable: several examples of counterintuitive trade patterns also appeared. Although some of these counterexamples required implausible assumptions (for example, figure 2-6), one (figure 2-4) required no more than the existence of transport costs and certain complementarities in demand. Thus, it could not be shown that the intuitive pattern of trade *must* arise, given any usefully general assumptions.

Nonetheless, enough cases exhibiting the intuitive pattern were found to make the Heckscher-Ohlin model a natural vehicle for explaining it. Differences in demand aside, the continuum-of-commodities version of the Heckscher-Ohlin model leads, in the presence of uniform transport costs, to the intuitive pattern of trade quite naturally.

The matter was pursued further here into the realm of models in which trade impediments differ among countries and commodities. Again, in several stylized models of trade and transport costs, the intuitive pattern of trade emerged 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.

Although the traditional two-dimensional Heckscher-Ohlin trade model is, by its size, inadequate to investigate issues of this sort, it can be generalized to include more goods, more countries, and even barriers to international trade. As such, it can be quite useful in explaining trade by developing countries. Nonetheless, there are no unambiguous explanations for what gives rise to the particular intuitive patterns of bilateral trade that have been observed. It seems that barriers to trade such as transport costs, while neither necessary nor sufficient for the occurrence of the intuitive pattern, are important in explaining it. More than that, it appears that the intuitive pattern of trade is most likely to arise when trade barriers exist but are smallest between countries of similar factor endowments.

Figure 2-1. *Intuitive Pattern of Trade*



Specialization matrices

	X_1	X_2	X_3	X_4
A	●	●	○	○
B	○	●	●	○
C	○	○	●	●

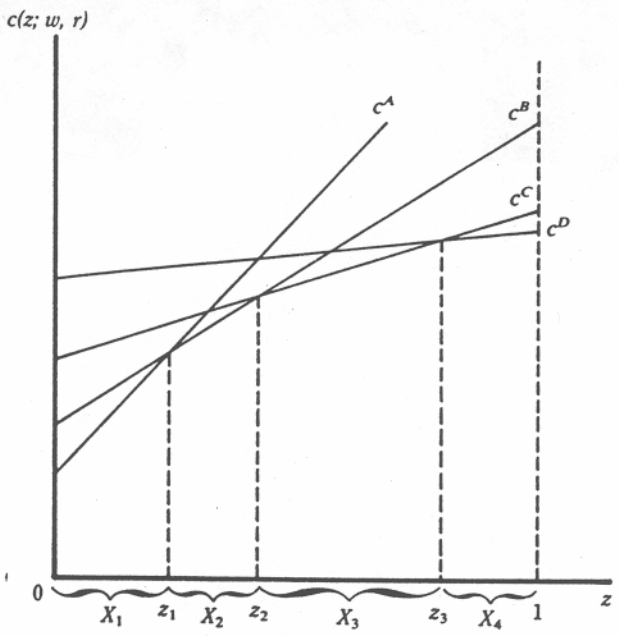
The intuitive case

	X_1	X_2	X_3	X_4
A'	●	○	○	○
B	○	●	●	○
C'	○	○	○	●

The neutral case

● Exported ○ Imported

Figure 2-2. *Continuum Model of Trade*

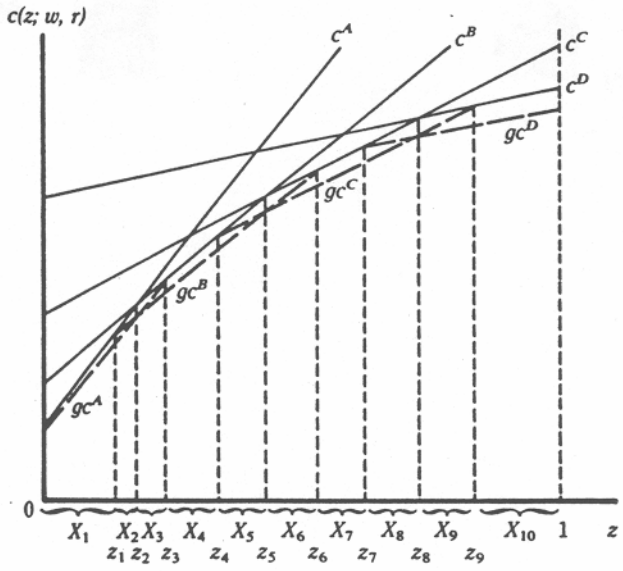


Specialization matrix

	X_1	X_2	X_3	X_4
A	●	○	○	○
B	○	●	○	○
C	○	○	●	○
D	○	○	○	●

● Exported ○ Imported

Figure 2-3. *Continuum Model of Trade with Transport Costs*



Specialization and trade matrix

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
A	●	●	■	○	○	○	○	○	○	○
B	○	■	●	●	●	■	○	○	○	○
C	○	○	○	○	■	●	●	●	■	○
D	○	○	○	○	○	○	○	■	●	●

● Exported ■ Produced but not traded ○ Imported

Figure 2-4. *Model of Trade with Demand Differences*

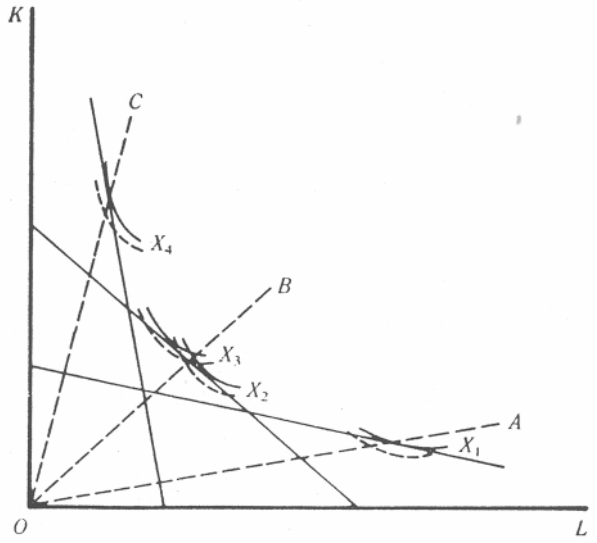


Figure 2-5. *Riverworld Model I*

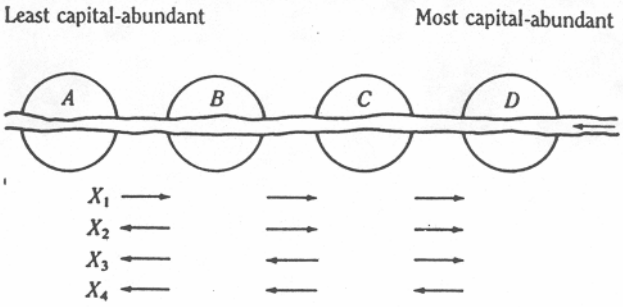


Figure 2-6. *Riverworld Model II*

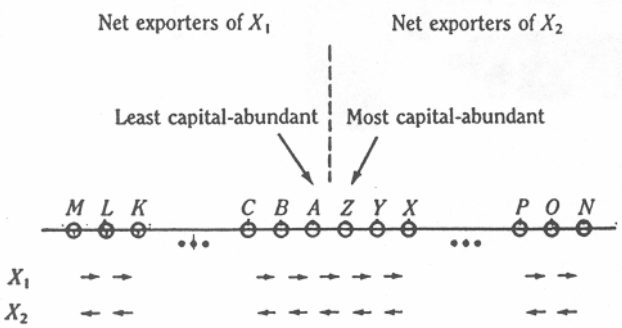


Figure 2-7. *Riverworld Model III: Transformation Curve for Middle Country*

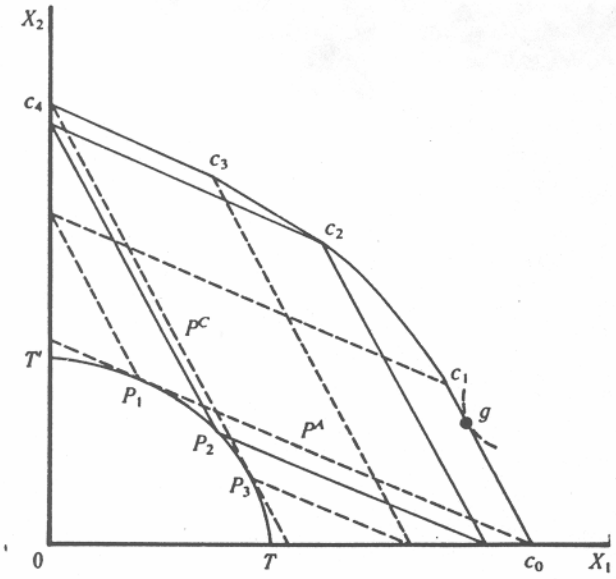


Figure 2-8. *World of Tiers Model*