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International Trade with Lumpy Countries

Paul N. Courant
Alan V. Deardorff

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DEPARTMENT OF ECONOMICS
University of Michigan
Ann Arbor, Michigan 48109

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We have received helpful suggestions from many colleagues in writing this paper. These include, but are not limited to, Joel Slemrod, Alasdair Smith, Bob Stern, Jerry Thursby, Marie Thursby, and others who participated in seminars at the University of Michigan, Purdue University, and the University of Western Ontario. Deardorff received partial support in writing this paper from the Ford Foundation.

ABSTRACT

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This paper explores the implications for the pattern of international trade of various differences among regions within countries—what we call lumpiness. It is shown first that if factors of production are immobile among regions, and if they are sufficiently unevenly distributed across these regions, then the pattern of trade of the country as a whole may depart from what it would have been had factors been perfectly mobile. Thus lumpiness in the geographical distribution of factors can be a determinant of trade. Second, the regional distribution of factors is made endogenous by assuming instead that they are mobile, but that differences now exist among regions in the levels of amenities that either attract labor or assist production. We show that such differences in amenities can cause the endogenous distribution of factors to be sufficiently uneven so as to influence trade. Thus lumpiness of amenities can be a determinant of trade. Finally, we introduce nontraded goods, which turn out also to influence trade. Thus lumpiness in the provision of nontraded goods is a determinant of trade.

Address correspondence to:

**Alan V. Deardorff
Institute of Public Policy Studies
The University of Michigan
440 Lorch Hall
Ann Arbor, MI 48109 - 1220**

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I. Introduction

International trade theory customarily assumes that countries are homogeneous entities. That is, trade theory abstracts from geographical, intra-country differences in factor endowments, consumer incomes and tastes, access to technology and resources, and the conditions of the environment affecting both producers and consumers.¹ Such differences are assumed either not to exist or not to matter, even though it is precisely these kinds of differences, when they arise across countries, that give rise to trade itself. In effect, it has been said, the countries of trade theory are points, with no physical dimension across which such differences could arise.

This neglect of intra-national differences may be justified if such differences are in fact small compared to the analogous differences that exist between nations. But casual observation suggests that in many cases there are far greater differences among regions of a single country than there are between comparable regions of different countries. It is the purpose of this paper to explore some of the implications of such differences for the pattern of international trade. In particular we shall show that various differences among regions within a country—what we call the lumpiness of countries—can, if they are large

¹See, however, Melvin (1985a, 1985b) for treatments that do include some of these differences.

enough, be a cause of international trade that is distinct from other more traditional determinants of trade such as differences in overall factor endowments and technologies.

A brief discussion of some of the regional differences that may exist should suffice to suggest the importance of examining them. Suppose, for example, that there are nontraded goods. "Nontraded" is usually taken to refer to international trade, but in fact the same considerations that make a particular good difficult to trade internationally—transport costs and, in the case of services, the need for on-site consumption—will also limit its trade among regions within a country. Furthermore, if some goods are nontraded among regions, then under some circumstances their prices will differ across regions. These price differences may in turn affect either costs of production or movement of population (or both) in ways that will affect trade.

Other important sources of regional lumpiness are the amenities that facilitate production or enhance life. Even very small countries often have substantial regional differences in climate, access to natural resources and recreation opportunities, or just the beauty of the environment. These are often important for producers and/or consumers.² Such differences, too, may have implications for trade.

But the simplest class of regional differences to consider, and the one that is often crucial in determining the role of the others, consists of regional differences in factor endowments. If factors of production are distributed unevenly over the countryside, then this of course will give rise to trade among regions within the country, exactly as predicted by the Heckscher-Ohlin (factor proportions) theory of international trade. We will argue further, however, that if such differences among regions are sufficiently large, then complete specialization of the regions themselves will occur, and this will lead the country as a whole to produce different quantities of goods than it would if factors were more

²That esthetics may be thought to matter even for production was illustrated by Assar Lindbeck a decade ago. He, we are told, declined an opportunity to move his Institute to more charming quarters on the grounds that his economists would be less productive with all that beauty to look at.

evenly distributed. This, in turn, can alter the quantities, and even the direction, of trade, compared to what it would have been in a more traditional model where regional differences play no role.

Throughout the paper, in order to focus clearly on the effects of lumpiness on trade and to abstract from all of the other factors that might give rise to trade, we will confine our attention to a very special case: a small open economy that, if it were regionally homogeneous, would not trade even if it could. That is, we consider as a benchmark case a country whose autarky prices, in the absence of differences among regions, would be identical to world prices. If introducing lumpiness then causes the country to trade, we can comfortably ascribe that trade to the effects of the lumpiness. Naturally, a corollary of all of our results is that a country which *would* trade if it were homogeneous could have its patterns of trade altered, perhaps even reversed, by lumpiness.

We also make several other assumptions throughout the paper. Preferences of all consumers are assumed to be identical and homothetic, so that consumer preferences can be aggregated independently of the distribution of income. All markets for both goods and factors are assumed to be perfectly competitive, and prices of both goods and factors adjust freely to equate supply and demand. Factor supplies are assumed to be perfectly inelastic, except where we explicitly consider movements of factors across regions, and factors are immobile internationally throughout. These assumptions keep the analysis simple, and also serve to make it comparable to most of the existing literature on the Heckscher-Ohlin trade model so that the distinctive role of lumpiness can be appreciated.

II. An Example of Trade Due to Uneven Factor Allocation

We begin with the familiar case of a small open economy that produces only two goods, both traded, using two factors of production, labor and land. There are no amenities to consider, and both factors are assumed initially to be distributed across the two regions of the economy in identical proportions. As our benchmark case, we assume

that world prices and preferences are such that, with free international trade, the country's trade in both goods is zero.

Figure 1 shows the transformation curve of the country as a whole, for producing goods X and Y, as the curve TT' . The relative price of good X on the world market is given by the slope of the dashed line labeled p (which is parallel to all other similarly dashed lines in the figure), tangent to TT' at Q^0 . A community indifference curve is also tangent to p at Q^0 , which is therefore also the country's consumption point, C^0 .

The country is divided into two regions, A and B, which for the moment are assumed to possess the factors of production, labor and land, in the same proportions as the country as a whole. This is illustrated by drawing the transformation curve of region A as $T_A T'_A$, relative to the same origin as TT' , and the transformation curve of region B upside down as $T_B T'_B$ relative to point Q^0 as an origin. Because these two regions have the same relative factor endowments as the country as a whole, their transformation curves are identical in shape to TT' and are tangent at a point, Z^0 , with the same relative outputs as Q^0 .

Now suppose that the relative factor endowments of the two regions are made unequal by moving, say, some of the labor endowment out of region B and into region A. If, as we now assume, good X is the relatively labor intensive good, then it is well known that such an expansion of the labor force in region A will cause its output of X to rise and its output of Y to fall, along the "Rybczynski Line," RR' . Suppose the new output of region A is given by the point Z^1 . In region B a similar process is occurring, but in reverse. Its output too will move along a Rybczynski line, but in the direction of reducing its output of X and increasing that of Y. In fact, with identical, linearly homogeneous technologies in both regions, it is well known that the changes in outputs of the two regions will be equal and opposite, so that point Z^1 also represents the new output of region B, drawn relative to the same set of axes as Z^0 .

Clearly the output of the entire country is unchanged by this exercise, and continues to be represented by point Q^0 . Thus it seems that a reallocation of labor out of region B and into A has not after all led to international trade, and thus that regional differences in factor endowments do *not* contribute to trade. There is interregional trade of course, each region trading with the other the difference between the outputs at Z^1 and their regional consumption bundles along the ray OC. But there is no international trade.³

However, this result of no trade arises only because we did not go far enough. Suppose instead that even more labor is reallocated between the regions, so that output of region A moves further down RR' to point Z^2 . It is now impossible for an equal and opposite change in outputs to occur in region B, for that would require negative output of good X. What happens instead, once enough labor is withdrawn from region B so that it completely specializes in good Y, is that further reductions in labor only reduce its output of Y. The result is that region B's transformation curve becomes the dotted one, shown together with a set of dotted axes in the figure, perched on its tip above the point Z^2 .

The country's output is now Q^2 , which is below and to the right of Q^0 . Since world prices have not changed, the country will continue to consume the goods in the same ratio as before, though subject to the somewhat reduced income that it earns by producing Q^2 . It therefore consumes at C^2 , and trades the differences between C^2 and Q^2 , as shown by the arrow in the figure.

Thus we see by this example that a sufficiently uneven allocation of factors between regions can indeed give rise to international trade. It remains to be seen, of course, how

³Interregional trade has generally been explained along the same lines as international trade, drawing heavily itself upon the Heckscher-Ohlin theory of trade. See Moroney and Walker (1966) for the seminal empirical analysis of interregional trade along Heckscher-Ohlin lines, and see Ho (1987) for a recent treatment and references to other literature. There is also quite a different literature on interregional trade, focusing on the role of cities as "central places" among which trade takes place. See for example Tinbergen (1968) and Ahn and Nourse (1988).

general this result may be, and what it is that has determined the pattern of the country's trade. This will be explored in the next section.

Before we leave this section, however, we should also note the pattern of interregional trade that has been generated. In the equilibrium at Z^2 , residents of region A (which include all those workers who have moved in from region B), produce the bundle at Z^2 but consume where the price line through Z^2 intersects the consumption ray OC. Thus region A exports substantially more of good X than does the country as a whole, the excess going to region B. Similarly, region B now produces only good Y, but exports part of that in exchange for X to region A. Thus the equilibrium includes both international and interregional trade.⁴

III. The Role of Regional Factor Allocation in International Trade

To explore further how the country's trade depends on the allocation of factors between regions, we turn to factor space in Figure 2. This is an elaboration of the familiar Edgeworth Production Box Diagram that has been used by Dixit and Norman (1980) and Helpman and Krugman (1985) to map out regions of specialization and nonspecialization. The horizontal dimension of the box is the labor endowment of the country as a whole, while the vertical dimension is the land endowment. Measuring the factor endowments of region A from the lower left (O_A) and of region B from the upper right (O_B), any point in the box indicates a particular allocation of factors between the regions.

As is well known from the Heckscher-Ohlin Model, given the world prices of goods X and Y and assuming the absence of factor intensity reversals, there will exist a single set of factor prices consistent with incomplete specialization and a corresponding pair of least-cost techniques of production for producing goods X and Y. Letting the ratios of land to

⁴There are many other aspects of this equilibrium that are of interest but that we haven't the space to discuss here. For example, a change in the terms of trade will affect the two regions quite differently, since what is an improvement for one region is a worsening for the other. Similarly there are differences in factor prices that will be noted below.

labor employed by these techniques be denoted t_X and t_Y , we draw rays t_X^A and t_Y^A from O_A and t_X^B and t_Y^B from O_B . For each region only those factor allocations that lie between these rays are consistent with their producing both goods. Therefore in the parallelogram $O_A R O_B S$ lie all of those factor allocations for which both regions can be incompletely specialized. Since factor prices are also equalized (and constant) within this area, we will refer to it as the FPE (factor-price-equalization) parallelogram.

The initial case considered in Figure 1 is now represented by an allocation such as E on the diagonal of the box. Here both regions are endowed with the factors in the same proportions. Their outputs of the goods can be inferred by drawing EF parallel to t_X and EG parallel to t_Y . Outputs of good X in regions A and B are then proportional to the lengths EF and $O_B G$ respectively, while outputs of good Y are proportional to lengths $O_A F$ and EG . From the geometry it is clear that the goods are indeed produced in the same proportions in the two regions.

An analogous construction for points off the diagonal but inside the parallelogram will indicate the output proportions in the two regions for other allocations consistent with incomplete specialization. Throughout the parallelogram, factor prices remain equalized and the total outputs of X and Y for the country remain constant. Above the diagonal, however, region A produces proportionately more Y than does region B , and A exports Y to B , even though the country as a whole does not trade.

The particular allocations at S and R will be of special interest. At these points both regions are just on the verge of complete specialization, with, at S say, all of the country's good Y produced in region A and all of its X produced in B . However, because the factor prices and techniques of production are the same here as elsewhere in the parallelogram, these outputs are the same as the totals for the country throughout the parallelogram. Hence the relevant isoquants for X and Y , drawn through S and R , provide convenient indicators of these outputs, which we label \bar{X} and \bar{Y} .

We now consider what the patterns of output and trade will be for allocations outside the parallelogram. The diagram is divided into several sections, within each of which we have identified representative locations by numbers 1-6. We have also recorded in parentheses next to these numbers the good, X or Y, that the country as a whole exports at that location.

Consider for example point number 1. As indicated by the small arrow leading to it, it can be reached from the parallelogram of nonspecialization by reallocating labor from region B to region A, leaving region A producing both goods but region B producing only Y. This is exactly the reallocation considered in Figure 1, where we saw that the country would export good X as a result. The result may be recalled here by noting that, in traversing the small arrow adjacent to point 1, output of X will rise in region A while remaining constant at zero in region B, and the output of Y will fall in both. Hence the ratio of X to Y produced in the country as a whole will rise, leading it to export X. Similarly, the same reasoning, with the names of the regions interchanged, will imply that the country will also export X at point 2.

Points 3 and 4 in the top and bottom of the Figure yield analogous conclusions by considering the change in land allocation needed to reach them. Point 3, for example, is reached from the border of the FPE parallelogram by moving land from B into A.⁵ Since A is producing both goods and B only X, output of labor-intensive X falls in both, while output of Y rises in A and stays constant at zero in B. Hence the ratio of Y to X produced in the country rises, and it exports Y. Exports of Y at point 4 can be similarly established.

Points 5 and 6 (and their unmarked analogs in the lower right of the Figure) must be handled somewhat differently. Using the \bar{X} and \bar{Y} isoquants for reference, it can be seen at point 5, for example, that region A produces less Y than \bar{Y} while region B produces

⁵Land is of course assumed to be immobile throughout this paper. When we "move land" in our analysis, we are really asking the hypothetical question of what the equilibrium would have been if more of the land had been located in, say, region A.

more X than \bar{X} . It follows that the country exports X. A similar argument shows that the country exports Y at point 6, with analogous results in the Figure's lower right.

In the space between the two isoquants we cannot know the pattern of trade. However, since outputs rise continuously and monotonically as one moves away from the origin, we do know that there will exist a well-defined locus of points in that space where the ratio of the two regions' outputs of X and Y are in the same ratio as \bar{X}/\bar{Y} . This locus is drawn as the dashed curve SM in Figure 2. Below it the country exports X, above it exports Y, and along the locus there is no trade. The locus SM is drawn as including the corner of the box at M, under the assumption that both factors are necessary in both industries in order to produce any output at all. If that is not the case—if output in either industry remains positive when one of the inputs is absent—then the locus may stop somewhere on the side of the box away from its corner.

This then maps out the patterns of trade for the country quite completely. The results are summarized in Figure 3, where the several areas with different trade patterns are separated by solid lines, and the more cumbersome details of Figure 2 are omitted. The Figure makes it clear that there exists a considerable variety of allocations of factors across regions for which the country will trade, and it also allows us to learn something about how this allocation matters for trade.

First, we note what was already evident in Figure 1, that factors do not need to be identically distributed across regions for there to be no trade. All that is required to be in the no-trade (FPE) parallelogram is for the factors of production to be sufficiently evenly distributed across regions.

On the other hand, it is also clear that there *will* be trade if the factors are sufficiently *unevenly* distributed across regions. Regardless of the sizes of the two regions (as reflected by distances from the respective origins O_A and O_B), if the distribution of one or both factors is sufficiently uneven, then there will be trade.

The next problem is to infer from the Figure what it is that determines the pattern of this trade. Noting that the areas where X is exported are near the right and left sides of the box diagram, while the areas where Y is exported are near the top and bottom, and recalling that good X is labor intensive, we suggest the following proposition:

Proposition 1: The country tends to export that good which uses relatively intensively the factor that is *more unevenly distributed* across regions.

This is not a very rigorous proposition, for we do not have a precise idea of what is to be meant by the term “more unevenly distributed.” Certainly if one were to consider variations in technologies and in the preferences of the country’s consumers for the two goods, the shapes and sizes of the various areas in Figure 3 would change markedly. A precise definition of “unevenly distributed” would therefore have to be formulated relative to these technological and demand considerations. However, the proposition does seem to describe, if only in a loose way, something that is important about the economics of the situation.

To understand this result, it is helpful to realize first that what we have here is an aggregation problem. Both regions of the country are behaving, individually, exactly like the familiar countries of the Heckscher-Ohlin Model. Trade of the country as a whole is then a weighted average of the trade of the two regions. When factors are unevenly distributed across regions, so that one is land abundant and the other labor abundant, then the two regions become exporters of different goods, and the net trade of the country as a whole depends on the weights attached to the two regions in aggregating them.

Suppose that labor is the more unevenly distributed factor, residing disproportionately in region B as in the left-hand portion of Figure 3. Then region B exports the labor-intensive good X, while region A exports Y. This alone would not tell us about the trade of the country as a whole. However, when we also note that most of the labor is in region B while land is fairly evenly distributed, it follows that region B is in an

important sense a larger economy than region A, and that its exports of X will dominate the country's trade.

Two-Country Trade

Until now we have considered a small open economy facing fixed prices. We should pause at this point however to indicate what trade patterns would look like in a two country world.

Suppose therefore that we have two countries with identical relative factor endowments, both initially with these factors identically distributed across their internal regions so that trade is zero between them at their common (autarky) prices. If factors were now shifted between regions within only one of the countries, then our analysis above would indicate not the equilibrium pattern of trade, but only the direction of the disequilibrium in world markets that would arise at the initial prices. For example, if labor were reallocated sufficiently between regions in one country as in Figure 1, then that country would come to have an excess supply of the labor intensive good X.

World markets would therefore have to adjust. As there is nothing in our model that is peculiar in terms of the shapes of the countries' supplies and demands (their offer curves), it follows that the new equilibrium will be found with a lower relative price of X. The lower price of X will induce the country where factors remain evenly distributed to import X, and will also reduce somewhat the amount of X that the first country exports. Naturally our pictures will no longer apply exactly to either country, since the world prices will not be the autarky prices for either.

The point of mentioning all of this is only to acknowledge that it is not only *uneven* distribution of factors in a country that will cause it to trade, but also a *more even* distribution of factors than elsewhere in the world. In this two country example, the country with the even distribution of factors nonetheless trades, as a result of the world price adjustment that has been induced by the uneven distribution of factors elsewhere. In particular, we can say that a country with an even distribution of factors will export the

good that uses intensively in production the factor that is more evenly distributed elsewhere.

Finally, we would note that this model is in no way a departure from the traditional principle of comparative advantage. While it is true that a lumpy country may trade in a direction that is contrary to the Heckscher-Ohlin Theorem, this trade is nonetheless completely consistent with the Law of Comparative Advantage. As the two country example illustrates, the country with more unevenly distributed labor will have a lower relative autarky price for the labor intensive good, and hence a comparative advantage in it.⁶

IV. Labor Mobility and Consumption Amenities

The results so far seem to depend crucially on the interregional immobility of both factors of production. If even one factor were mobile and could move across regions to seek the highest return, then trade would no longer occur.

For example, suppose again that labor were disproportionately distributed into region B sufficiently to cause region A to produce only Y and the country to export X. Then the wage of labor in region A would be higher than in region B, where continued nonspecialization would still determine a wage equal to that abroad. If labor could move, it would presumably depart from B and move into A, moving us to the right in Figure 3. This movement would continue until wages become equalized, which occurs only in the FPE parallelogram. Thus this parallelogram, which we already identified as the region of no trade, becomes the set of equilibrium factor allocations if factors move to equalize their factor prices across regions.

This result can be turned on its head, however, if workers respond to something else in addition to wages in deciding where to live, and if this something else differs across regions. Obvious candidates for this "something else" are the prices of nontraded goods,

⁶This model is, like many others, a special case of the model examined by Deardorff (1980).

which we will consider later in the paper. For now however we opt for simplicity by assuming that there is some unspecified “amenity” that matters for consumers⁷ and that differs in its availability across regions. One could think of this amenity as being the region’s climate, though anything that affects the quality of life could play the role as well.

The basic story is then very simple: Suppose, say, that region B is nicer to live in than region A. Then workers will move there, not until they equalize the wages across regions, but until there is a sufficient real wage differential to induce some of them to stay in region A. This in turn means that we *must* leave the FPE parallelogram, and that labor-market equilibrium will be found *only* among those regional factor distributions that lead to trade.

Somewhat more formally, assume that the (common) preferences of consumers everywhere are represented by an indirect utility function $V(p, E, \Gamma)$, where p is the vector of prices of goods in some numeraire, E is the level of consumer expenditure in the same units, and Γ is the level of the amenity in the region where the consumer lives. Letting w^I and Γ^I be the wage of labor and the level of the amenity in regions $I=A, B$ respectively, then the condition for labor market equilibrium is

$$V(p, w^A, \Gamma^A) = V(p, w^B, \Gamma^B) , \quad (1)$$

where p is the vector of goods prices that is common to the two regions. This equation can be solved for either wage in terms of the other wage, the price vector and the two amenity levels. However, for simplicity assume that the indirect utility function has properties such that the solution takes the following form:

$$w^A - w^B = \gamma(p, \Gamma^A, \Gamma^B) . \quad (2)$$

Looking now at Figure 4, we can say more about the location of the labor market equilibria. Figure 4 reproduces portions of Figure 3, with particular attention to the locus MS that separates exports of X from exports of Y in the north-west corner of the box.

⁷But not, directly, for producers. Production amenities will be considered in Section V.

Suppose again that region B has the higher level of amenities, so that $\Gamma^B > \Gamma^A$ and labor market equilibrium requires

$$w^A - w^B = \gamma^1 > 0 . \quad (3)$$

This condition will hold along the locus $O_A F U G O_B$. This locus begins from O_A with a straight segment, $O_A F$, since in this area the wage in region B is constant due to FPE, while the wage in A depends only on the land-labor ratio in A. The locus also ends in a straight segment $G O_B$ for the same reason. Between F and G we know only that it must move, from F, to progressively lower land-labor ratios in both regions in order for both wages to move in the same direction. This is enough to assure that the locus crosses the curve MS only once.

With the distribution of land fixed and labor mobile in this fashion, the equilibrium pattern of trade will be determined along this locus by the given distribution of land. As long as the distribution of land is below point T_A^1 in the figure, the country will export X. Above that it will export Y. As drawn, it appears that the range of possible land distributions that will lead the country to export X is greater than the range that will lead it to export Y, suggesting a bias in favor of exporting the labor-intensive good.

Such a bias is to some extent an artificial result depending on how we happened to draw the figure. However it becomes more systematic as we consider differences in amenities that are more and more extreme. For example, if the amenity difference were such as to require a wage differential $\gamma^2 > \gamma^1$, then the locus of labor-market equilibria would be shifted out further from the FPE parallelogram, to something like $O_A U' O_B$. This locus crosses MS higher in the figure, increasing the range of land allocations for which the country will export X. As we consider ever larger differences in amenities, therefore, we can conclude that

Proposition 2: If labor is mobile in response to a difference in consumption amenities across regions, then the larger is that difference, the more likely it becomes that the country will export the labor intensive good.

Congestion

The amenities we have considered so far have remained constant in their effects even as more and more labor has moved into a region to take advantage of them. For some amenities, such as climate, this may be reasonable. For others such as recreation facilities it certainly is not. And in any case, once one begins to consider amenities that enhance the quality of life, one should equally well consider the adverse consequences of population density. Therefore in this section we take note of how our analysis would be altered if we were to allow for congestion of the amenities.

The effect is quite straightforward. When labor was allowed to move in response to a “pure public amenity,” it had to move all the way outside of the FPE parallelogram in order to create a compensating wage differential. The reason was that within the FPE parallelogram wages do not change at all as factors move. This continues to be true even when we allow for congestion. But what congestion *can* do is to remove the need for any change in wages.

To allow for congestion, we now let the indirect utility function take the form

$$V = V(p, E, \tilde{\Gamma}(\Gamma, L)) \quad , \quad (4)$$

where $\tilde{\Gamma}$, the level of the amenity available to the consumer, is increasing in Γ and decreasing in L , which we assume varies directly with population.

Suppose then that we start with an even distribution of factors across regions, as at point E in Figure 2, and that the consumption amenity favors region B. Workers will begin to move into region B, as before, but as they do the value of the amenity to consumers will be eroded by congestion. At the same time, as workers leave region A, fewer and fewer people will share the amenity there, and its value to them will be enhanced. It is possible, therefore, that the value to consumers of the amenities will become equalized solely by labor movement, before that movement leads to complete specialization in either region. If so, then trade will remain zero and the original difference in amenities will not have led to trade.

Thus, the role of congestion of a consumption amenity is to reduce the likelihood, for any given difference in that amenity, that it will lead to trade. Recalling that without congestion even the smallest difference in amenities would lead to both complete specialization in some region and trade, it is perhaps reassuring that congestion can dampen this extreme effect somewhat. Notice that it continues to be true that differences in consumption amenities *can* lead to trade: they merely have to be large enough.

V. Production Amenities

Amenities do not exclusively affect consumers, of course. In some industries climate is as important for production as it is for the quality of life. In others the proximity to natural resources may serve to reduce costs. And as footnote 2 above suggested, workers' productivity may be influenced by the environment in which they live and work.

To allow in our analysis for such production amenities raises more questions than does the simple consumption amenity discussed in the preceding section. Are production amenities equally important for both industries, or do they favor one over the other? How does the amenity enter the production function of an industry—is it like another factor with respect to which there are diminishing returns, or is it like an efficiency parameter affecting outputs at all scales identically? And finally, what effect does the amenity have on demands for factors—is it labor-saving, land-saving, or neutral, and, if neutral, in what sense? In short, the presence of production amenities raises all of the questions traditionally associated with technological change, and it could therefore lead us into an almost unending proliferation of cases to consider.

We shall therefore not attempt to pursue the subject of production amenities exhaustively, but rather will examine only the simplest possible case. Our purpose is not a definitive evaluation of the roles that production amenities may play in determining trade patterns, but only to check that they do not necessarily undermine the conclusions we have already arrived at without them.

Thus, consider a production amenity that plays the role of a Hicks-Neutral technological shift parameter of the same size in both industries.⁸ That is, we write the production functions for X and Y respectively as

$$X^I = \Gamma^I F(L_X^I, T_X^I) \quad (5)$$

$$Y^I = \Gamma^I F(L_Y^I, T_Y^I) \quad (6)$$

for regions $I=A,B$. Thus the level of the production amenity, Γ , serves to determine the numbering of the isoquants for each good, but it does not change their shapes. In addition, we assume that the difference in the amenity has the same percentage effect on both industries.

These assumptions serve to leave the regions of specialization shown in Figure 2 unchanged. Because only the numbering of isoquants is changed, and because the percentage effects are the same in both industries, it follows that the land-labor ratios consistent with nonspecialization, t_X and t_Y , are the same in both regions in spite of the production amenity. However, the implications of these patterns of specialization for trade *are* changed by the amenity, as we now discuss.

Figure 5 shows the regions of specialization as before, bounded by the various t_X and t_Y rays. Suppose now that the level of the production amenity is greater in region B than in region A, so that outputs in B, for given inputs, are some $\theta\%$ higher than in region A.

Consider first the diagonal of the box diagram, $O_A O_B$. Along it, both regions produce the goods in the same proportions. Hence, even though region B can produce θ percent more of both goods from a given amount of factors, the ratio of the goods produced

⁸Such an amenity plays the same the role in production as a "factor-augmenting intermediate public good." See Feehan (1989).

in the whole economy will be the same. Thus there will be no trade anywhere along this diagonal line.⁹ This is the same result that we had without the production amenity.

Off the diagonal, however, things are different. Consider allocations above the diagonal, though still consistent with nonspecialization in both regions, in the triangle $O_A O_B S$. Here region A, without the amenity, produces relatively more of the land-intensive good, Y, than does region B, while region B produces relatively more X. Since B has the greater amenity, the output of the entire economy will be biased towards good X. To see this, suppose for comparison that region B did *not* have an amenity advantage over region A, and that its production levels were then X^C and Y^C . Letting $\bar{X} = X^A + X^C$ and $\bar{Y} = Y^A + Y^C$ we know from our earlier analysis that \bar{X}/\bar{Y} is the ratio of the goods both produced and consumed along the diagonal. With the amenity advantage, however, $X^B = (1+\theta)X^C$ and $Y^B = (1+\theta)Y^C$. Therefore

$$\begin{aligned} (X^A + X^B)/(Y^A + Y^B) &= (X^A + (1+\theta)X^C)/(Y^A + (1+\theta)Y^C) \\ &= (\bar{X} + \theta X^C)/(\bar{Y} + \theta Y^C) \\ &> \bar{X}/\bar{Y} \end{aligned} \tag{7}$$

since $X^C/Y^C > \bar{X}/\bar{Y}$ above the diagonal. Similarly the country will export good Y for nonspecialized allocations below the diagonal. These results are noted in Figure 5 by recording the identity of the good that is exported in each area in parentheses.

In areas where one or both regions are completely specialized, one needs merely to compare their outputs to the earlier analysis. For example, near the left of the diagram where good X was previously exported, this will still be the case since region B, whose production is elevated by the superior amenity, is already producing a higher ratio of X to

⁹While the ratio of goods produced will be constant along the diagonal, the total amounts produced will not. The closer the economy is to the lower left corner of the box, O_A , the more production will take place in the more productive region B, and the greater will be the country's output of both goods.

Y than the country as a whole. Similarly, near the bottom of the diagram, where good Y was exported, this too will continue to be true for the same reason.

However, the presence of the production amenity can change the trade pattern from our earlier analysis for those allocations where region B was previously exporting the opposite good of the country as a whole. For points just above point S, for example, without the production amenity we had region B specializing in X but the country exporting Y. With the output of X in B now elevated by the amenity, the country will now export X instead. Thus the borderline between exporting X and exporting Y is now shifted upward toward the top of the box. Similarly, the analogous borderline on the right hand side is also shifted towards to the right. These new borderlines are now shown in Figure 5 as MFO_B and O_BGN .

The result, then, is that the introduction of a production amenity that differs across regions, even without any mobility of factors, can increase the likelihood of trade. Comparing Figure 5 to Figure 3, the area of no trade, which previously included the entire FPE parallelogram, has now degenerated to the diagonal line. We therefore get trade arising for “almost all” allocations of factors of production. The pattern is largely similar to that without the production amenity, although some of the areas denoting particular patterns of trade have now expanded to encroach on others. In particular, our statement in Proposition 1 still appears to be correct for sufficiently uneven factor allocations: trade continues to result from the uneven distribution of factors across regions, with some tendency for the country to export the good that uses intensively the more unevenly distributed factor. This is supplemented however by another tendency that applies for factor distributions that are closer to even, and that we now state as an additional proposition:

Proposition 3: When regions differ in both levels of production amenities and relative factor endowments, there is a tendency for the country as a whole to export the same good that is exported by the region with the greater amenity, that is, the good

which uses relatively intensively the factor with which that favored region is relatively well endowed.

What is perhaps surprising about this result is that it is true independently of the sizes of the regions. Even if the high-amenity region is quite small in absolute terms, as in the neighborhood of the corner O_B in Figure 5, it is still true that the country will export the same good exported by region B so long as both regions produce both goods.¹⁰

Labor Mobility

A consumption amenity had no effect on the country's trade until we also allowed labor to be mobile between regions. As we have just seen, a production amenity gives rise to trade even with both factors immobile. However it is of interest to note, in passing, how labor mobility would now matter for trade in the presence of the assumed production amenity.

Without any consumption amenity, labor will move between regions to equalize the wage. However, the presence of the production amenity means that wages cannot become equal while both goods are produced in both regions. With the assumed Hicks-neutral amenities wages (and rents) are elevated along with output, and by the same percentage. Thus while the ratio of the wage to the rent on land is the same in both regions throughout the FPE parallelogram $O_A R O_B S$ in Figure 5, both the wage and the rent are higher in B than in A by the percentage θ . Labor will therefore be induced to move out of A and into B, moving us to the left in the Figure, exactly as was the case with the consumption amenity though for quite different reasons.

As before, labor market equilibrium will be found along a locus very similar to $O_A F U G O_B$ in Figure 4. That is, equilibrium can only take place outside the FPE parallelogram. To avoid clutter we do not draw it in Figure 5, but it should be clear that its properties and implications are very much the same as was the case in Figure 4. In

¹⁰Indeed, as is shown in Figure 5, this trade pattern will also exist for allocations sufficiently *near* to the FPE parallelogram, not just in it.

particular, for a large range of allocations of land, the production amenity provides an incentive for labor to move the economy to allocations for which it will export the labor intensive good. In addition, as the difference in production amenities becomes larger, the locus MFO_B is pulled upward toward the top of the diagram, and the range of land allocations for which the country exports X increases. Therefore Proposition 2 is valid also for differences in production amenities. Since many amenities benefit both producers and consumers, this is reassuring, for it means that such mixed amenities will also have a well-determined effect on the pattern of trade. Also, this suggests that production amenities will lead to higher population densities. In other words, places that have natural advantages in production will tend to become cities, a finding that is at the heart of regional and urban economics, and also is consistent with observation.

VI. Nontraded Goods

The effect of nontraded goods on international trade depends importantly on whether the factors used to produce them are the same as the factors used to produce traded goods. If so, then the mechanism of factor price equalization serves also to equalize the prices of nontraded goods across regions. Even in this case, however, the presence of nontraded goods can have important effects. As we show in another paper¹¹, the presence of nontraded goods reduces the size of the FPE parallelogram and therefore, even without labor mobility, increases the likelihood that lumpiness will effect the pattern of international trade.

Here we consider the polar opposite case: where nontraded goods are produced using only factors of production that are different from those used in traded goods.¹²

¹¹Deardorff and Courant (1989).

¹²We realize this case is unrealistic. However, as long as *some* of the factors used in producing nontraded goods are not used to produce traded goods, then our qualitative results below will carry through.

Suppose, then, that in addition to goods X and Y there is a third good, N, that is nontraded even between regions. Suppose also that production of this good requires neither labor nor land, but instead any number of additional factors of production, denoted by a vector R, that like land are also immobile between regions. Letting the production function for N be $H(R)$, the fixed factors available for its production then imply a fixed amount of it that will be produced. Henceforth, therefore, we will regard the supply of N itself as fixed, and ignore the underlying process of production.

Like the amenities that we have considered earlier, nontraded goods may be consumption goods or they may be intermediate inputs to production. We will assume the former, leaving the analogous case of intermediate inputs to the reader.

On the consumption side, then, let the indirect utility function be $V(p,q,E)$, where p is the vector of prices of traded goods, q is the price of the nontraded good, and E is total expenditure in the region. This expenditure must include both the incomes of labor and land, plus the income of the resources used to produce N. Since the latter is qN , we have

$$E = wL + rT + qN \quad (8)$$

Equilibrium in the market for the nontraded good requires that its demand equal its fixed supply, or that

$$\begin{aligned} N &= -V_q(p,q,E)/V_E \\ &= -V_q(p,q,wL + rT + qN)/V_E \end{aligned} \quad (9)$$

where V_q and V_E are the partial derivatives of V with respect to q and E , and V_E , of course, depends on the same arguments as V_q . The fact that the demand for N depends positively on the income generated by its production opens up the familiar possibility of non-unique and unstable equilibrium. However, we assume that away, so that this equilibrium condition can be solved for q in terms of the other variables present. As we

will be interested only in its dependence on N and L , we write this solution and use conventional properties of demand functions to sign its arguments as follows:¹³

$$q = q(N, L) \quad (10)$$

If we now substitute this solution back into the indirect utility function itself, we get

$$V = V(p, q(N, L), E) \quad (11)$$

Equation (11) is of exactly the same form as equation (4), from which it is clear that the nontraded good acts in exactly the same manner as a congestible consumption amenity. If the resources for producing the nontraded good are located disproportionately in one region of the country, then its price will be low there and this will attract an inflow of labor. That inflow of labor, however, serves in turn to raise the demand for the nontraded, and thus its price, and therefore has the same offsetting effect as congestion of an amenity.

We conclude therefore that we do not need an extensive analysis of this kind of nontraded good. Its effects on trade have already been established implicitly in our discussion of consumption amenities. These effects need merely to be translated into the present context:

Proposition 4: If regions are disproportionately endowed with the resources needed for producing nontraded goods, and if labor is mobile, then price differences for nontradables will cause labor to move among regions to make the distribution of factors for producing tradable goods uneven. If the difference in resource endowments is large enough, then prices of nontraded goods will remain unequal even after labor has moved, equilibrium will be achieved by complete specialization among tradables in one or both regions and a compensating wage differential between regions, and the country will trade. The greater is the difference in nontraded goods prices that persists after this adjustment, the more likely it is that the country as a whole will export the labor intensive good.

VII. Conclusion

This paper has been about various forms of lumpiness of countries and how these can contribute to international trade. By lumpiness we mean in general any differences

¹³Much more precision is possible if preferences happen to be Cobb-Douglas. In that case $q = [\alpha/(1-\alpha)]wL+rT/N$, where α is the expenditure share of the nontraded.

across regions of a country that may cause them to produce or consume differently.

Among our conclusions are the following:

Lumpiness of factor endowments can cause trade. The more uneven is the distribution of factor endowments across regions of a country, the more likely it is that regional differences in specialization will lead the country as a whole to trade. When this happens, the tendency is for the country to export the good that uses intensively the factor that is the most lumpy, which is to say, the factor that is the most unevenly distributed.

Lumpiness of consumption amenities can cause trade, if labor is mobile across regions in pursuit of these amenities. Differences in the levels of consumption amenities across regions tend to cause labor to become unevenly distributed, and thus cause the country to export the labor intensive good. This tendency can be undermined if the consumption amenity is congestible, but it will survive even in the presence of congestion if the difference in amenities is large enough.

Lumpiness of production amenities can cause trade. Even small differences in production amenities, if they are of the particular neutral form considered in this paper, will cause a country as a whole to export the same good that is exported by the region with the superior amenity. If production amenities differ more substantially across regions, then this reinforces the earlier tendency for the country to export the good that uses intensively its more unevenly distributed factor. Finally, if there are differences in production amenities and labor is mobile, then in order to equalize the wage labor will move to achieve specialization, and there will be a tendency to export the labor intensive good.

Finally, lumpiness in the provision of nontraded goods can cause trade. If nontraded goods use resources that are different from the factors used to produce traded goods, and if these resources are unevenly distributed, then their prices will differ across regions and have the same effects on the economy and on trade as a congestible amenity. With mobile labor, for example, differences in prices of nontraded goods will tend to lead a country to

export labor intensive goods, as labor will be attracted disproportionately to the region where nontraded goods are cheap.

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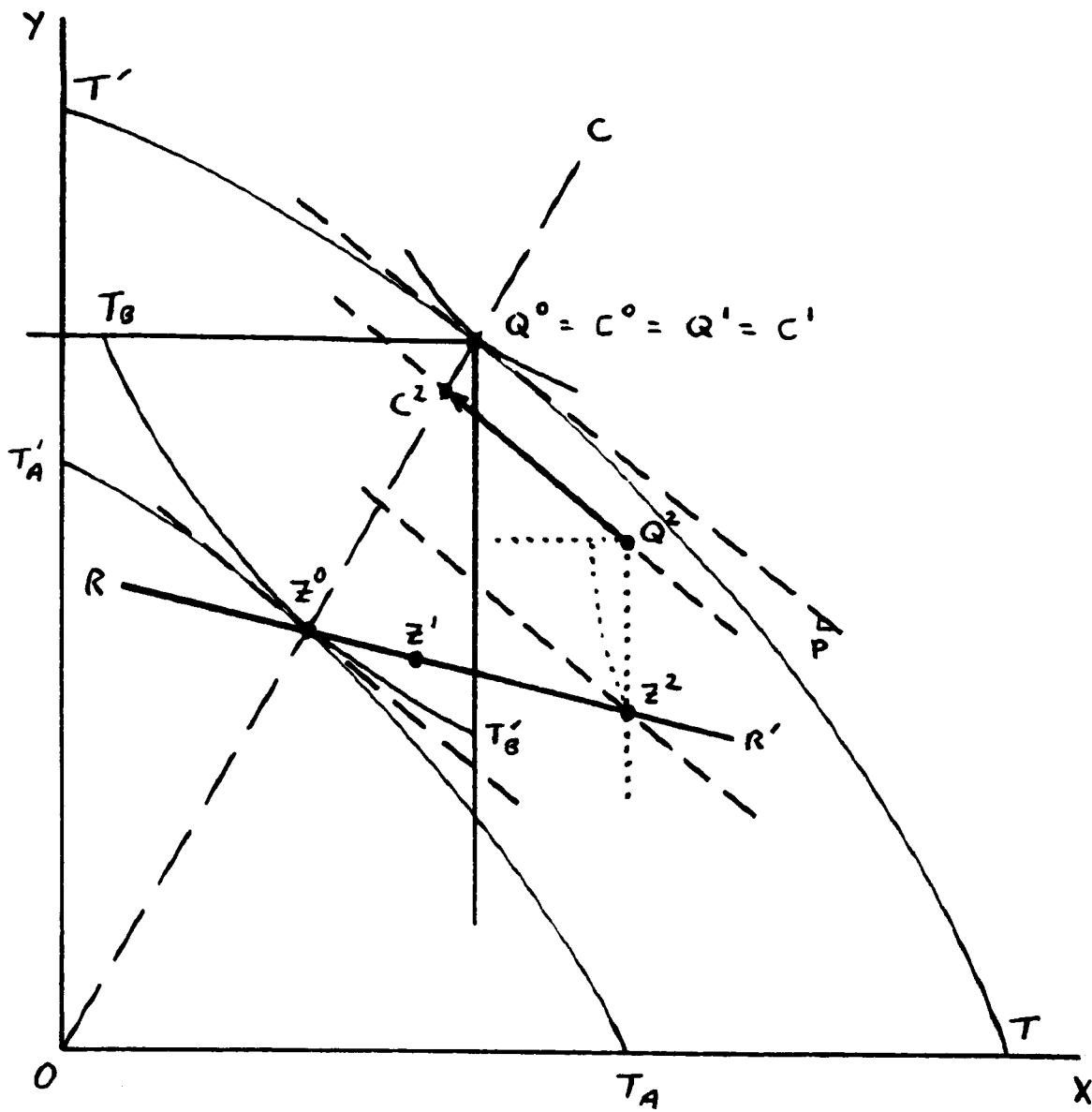


Figure 1

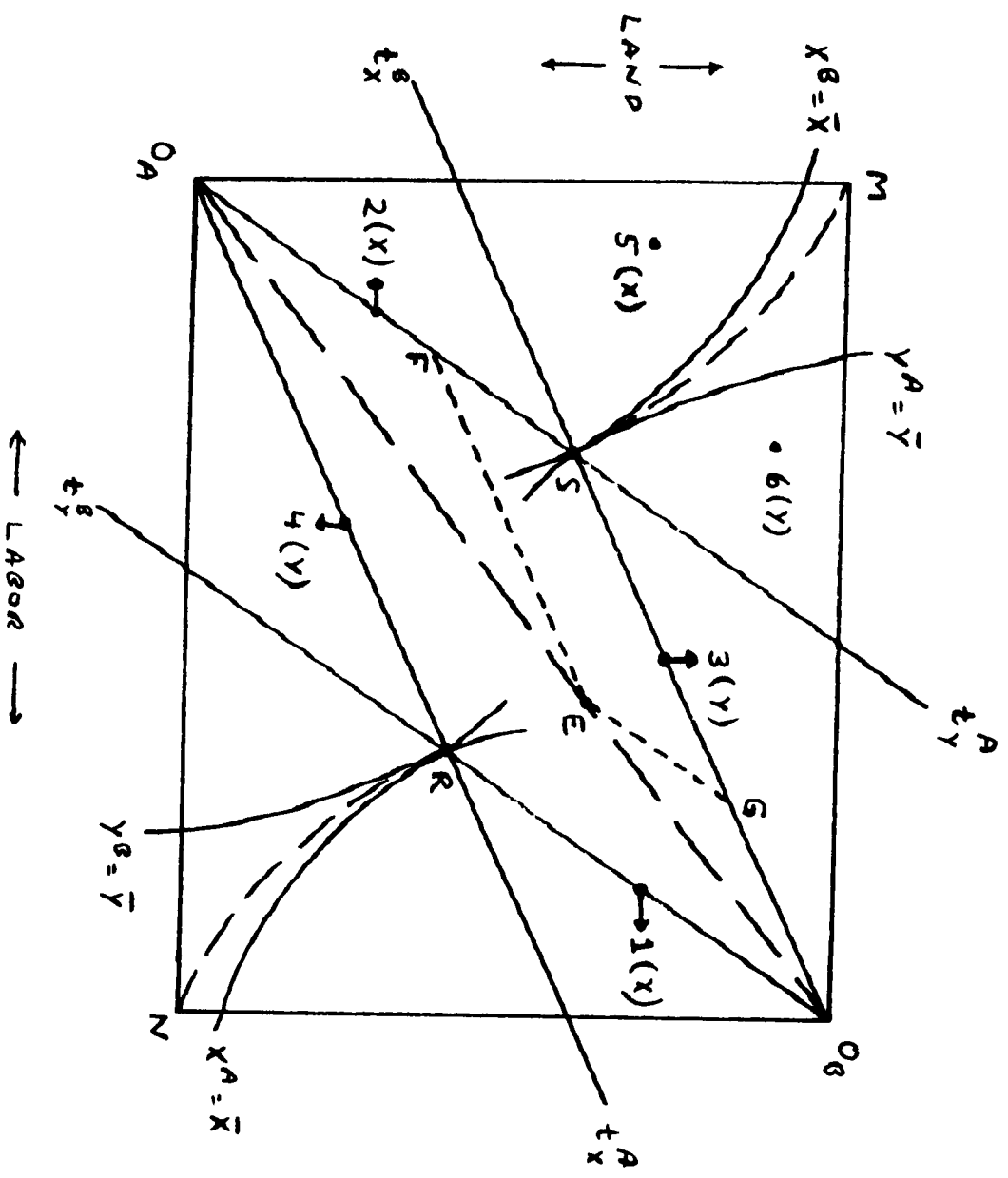


Figure 2

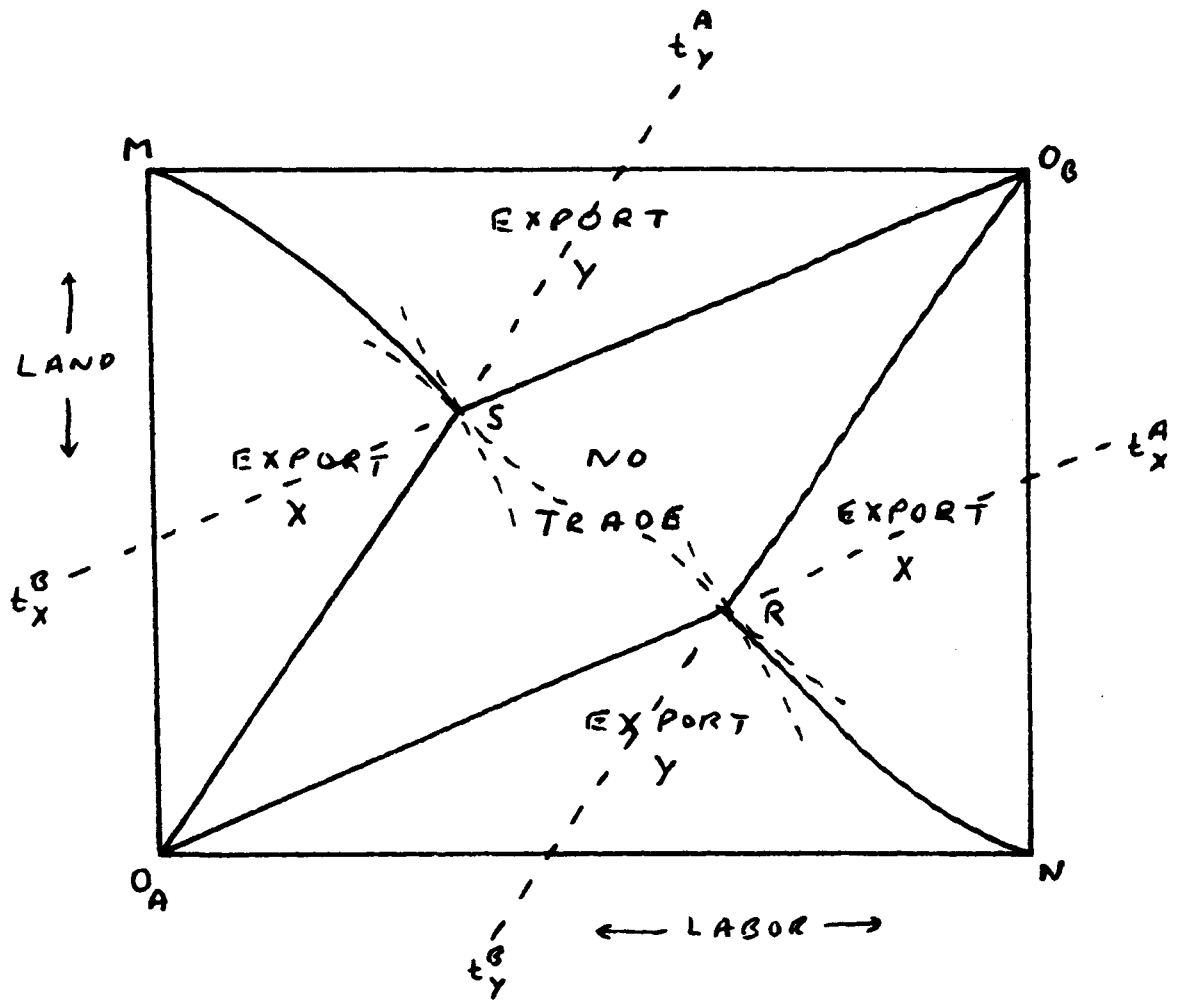


Figure 3

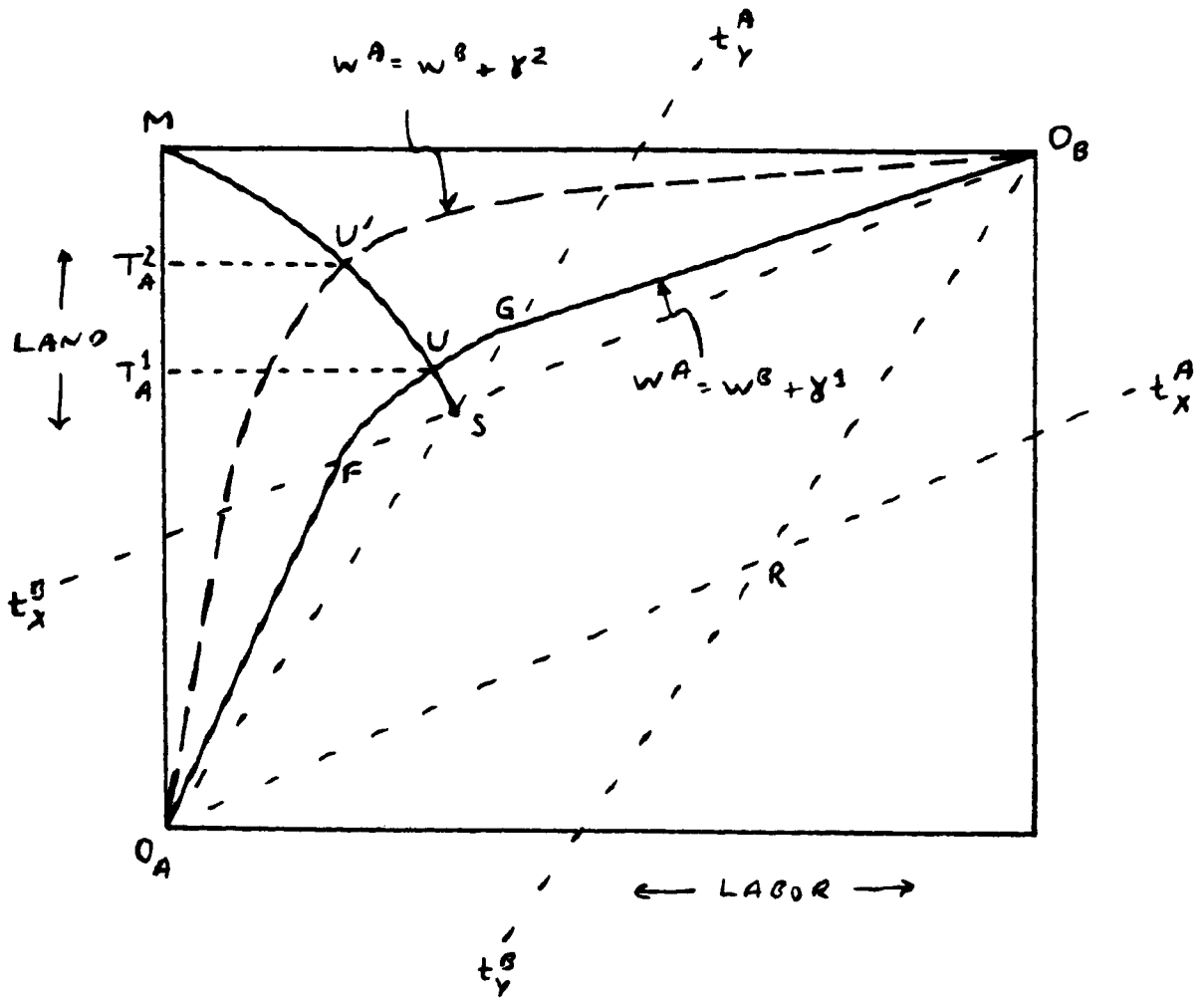


Figure 4

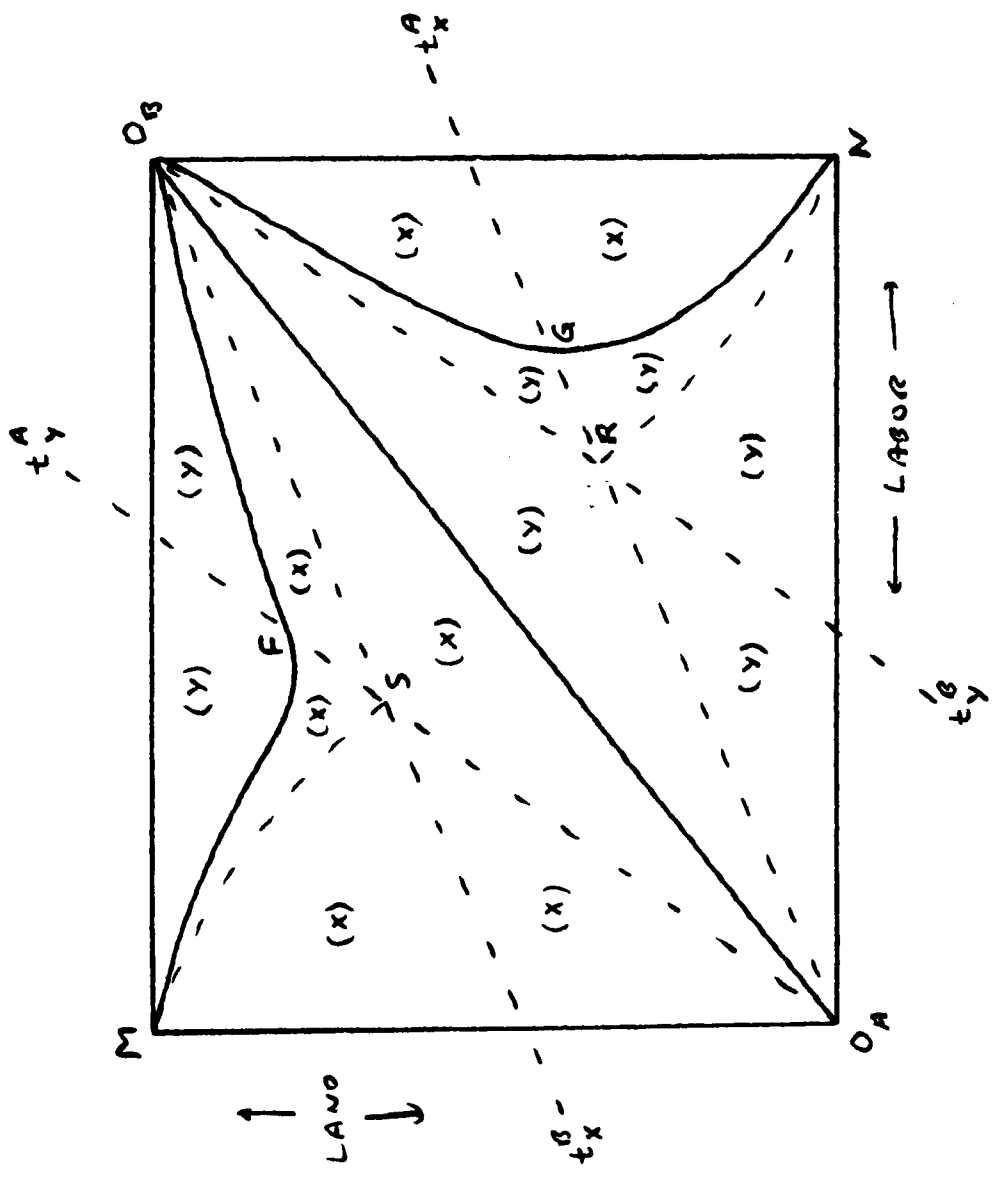


Figure 5

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