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TRADE AND FACTOR MOBILITY WITH INCREASING RETURNS TO SCALE

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1. INTRODUCTION

This paper examines equilibrium and changes in equilibrium in international trade under conditions of increasing returns to scale in production. The first section of the paper solves for stable equilibrium positions between two trading partners; the reader should find this section a refinement and development of Matthews (1950) work. The second section discusses inter-country and intra-country factor mobility and examines various equilibrium and welfare positions. The role of increasing returns to scale in urban and regional production as opposed to their role in international trade is discussed. Also, the concept of equilibrium unemployment is examined. Finally the Stolper-Samuelson and Ryczynski theorems are re-evaluated for increasing returns to scale in a brief summary emphasizing the economic interpretation of the results in Jones (1968).

The following assumptions will be maintained throughout the paper. Technology is the same between countries for the two produced goods. The two countries are endowed with fixed quantities of the two factors of production. Within and between countries, factor returns are spent by individuals who have identical tastes and whose indifference curves are homothetic. This assumption allows us to use community or world indifference curves as a measure of potential welfare.

Both goods are produced under increasing returns to scale specified as economies of scale external to the firm and internal to the industry. This means that the subjective production function for the firm is

$$x_i = g_i(X_i)\cdot F_i(l_i,k_i), \quad x_i = 0 \quad \text{if } l_i,k_i = 0 \tag{1.1}$$

where x_i is the output of the i^{th} firm, X_i is the output of the i^{th} industry, and k_i and l_i are respectively firm inputs of capital and labour. F_i is the firm's linear homogeneous production function and g_i represents externalities where $\partial g_i/\partial X_i$ gives the effect on the productivity of a firm in the i^{th} industry of a change in the output of the i^{th} industry.

Because scale economies are external to the firm, g_i is not a function of x_i but only of X_i. Given free entry of firms at the current g_i and because no firm is aware of the downward slope of its cost curve, perfect competition and full payment of factors is preserved. However, because the firm is unaware of the externality, $\partial g_i/\partial x_i$, a potential divergence arises between private and social marginal cost, if the degree of increasing returns to scale varies between industries, where we define the degree of increasing returns to scale to be

$$1 > R_i = X_i \partial g_i/\partial X_i g_i > 0, \quad \text{for external economies} \tag{1.2}$$

$R_i < 1$ so that total (though not average) costs of production always rise as output rises. The divergence between private and social marginal costs can be eliminated by an appropriate set of taxes and subsidies. These points are documented in Chipman (1970).

The industry production function is defined as

$$X_i = g_i(X_i) \cdot F_i(L_i, T_i) = G_i(L_i, K_i) \tag{1.3}$$

where capitalized letters refer to industry variables. G_i is a homothetic function and unless it is otherwise specified, this assumption of Hick's neutral scale economies will be maintained.

2. STABLE EQUILIBRIUM IN TRADE

In this section we show that production scale economies, independent of factor endowments, are an important determinant of trade. In any discussion of autarky or trade equilibrium with scale economies, the analysis of stability of equilibrium always plays a crucial role. Utilizing a market adjustment mechanism in the discussion of stability, we can show that a country may lose from trade under atomistic competition if it is not completely specialized in production.

We initially isolate the basic concepts needed to determine trade equilibrium between two countries. To do this we assume that the degree of increasing returns to scale, R_i, is equal between industries so that there is no divergence between private and social marginal costs and we assume that the returns to scale are strong enough to make the transformation curve globally convex to the origin.[1] If the transformation curve is concave to the origin in the relevant range of production and trade, the analysis is qualitatively unchanged from the constant returns to scale case. Finally we assume that the countries are of equal size which will allow us to demonstrate that increasing returns to scale, as well as varying relative factor endowments, are a determinant of trade.

Let us first examine the closed economy equilibrium position before trade is introduced. In Figure 1, if A is the initial closed economy equilibrium point, is it a stable point? To answer that question we must specify a market adjustment mechanism that makes it possible to move from a disequilibrium point back to the initial equilibrium or onto a new equilibrium. We assume a Walrasian type of market mechanism. In terms of Figure 1, one day

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1. See the second and third paragraphs of section 4 of this paper for a complete discussion of what the convexity assumption implies.

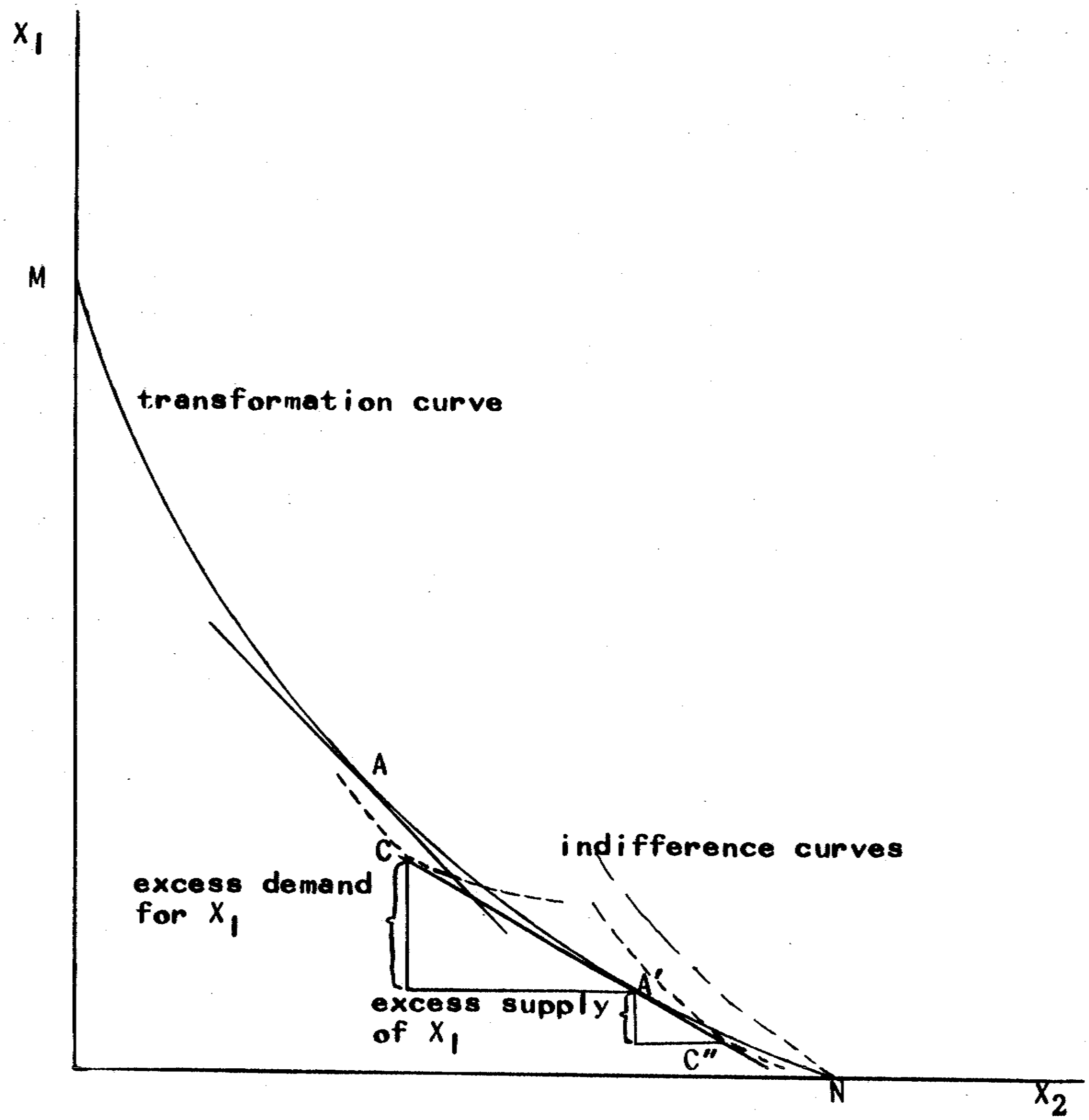
X_1
M
transformation curve
A
C
indifference curves
excess demand
for X_1
A'
excess supply
of X_1
C"
N
X_2

Figure 1

producers of the country come to market with non-equilibrium quantities of goods such as indicated by A', where the relative cost of X_2 has fallen. At the new quantities and cost ratios consumers wish to consume at points such as C' or C", resulting in excess demands at the end of the market day. If there is an excess demand for X_1, as at C', the consumer price in the market for X_1 will be driven up so that it is higher than the relative cost of X_1 at A'. These profits in the X_1 industry will lead producers to expand production of X_1 for the next market period and return to equilibrium, given an appropriate adjustment time and path. Note that in this case the consumer-community indifference curves locally have a greater degree of curvature than the transformation curve or the elasticity of substitution of commodities in production which is negative under convexity is locally greater in absolute value than the negative elasticity of substitution in consumption.[2]

If the community-indifference curves have a smaller degree of curvature than the transformation curve, then at A' there is a negative excess demand for X_1. The resulting rise in the market price of X_2 relative to its cost at A' induces a further movement from A towards N. If indifference curves have a smaller degree of curvature globally than the transformation curve, stable equilibrium occurs at N or M where the community indifference curve cuts the X_2 or X_1 axis[3] with a higher community indifference curve than at A (not shown in Figure 1). We have no market mechanism for choosing between M and N as equilibrium points, regardless of which yields the highest welfare level.

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2. Given homothetic indifferences curves and identical tastes, the elasticity of substitution in consumption defines consumption technology.

3. The indifference curve cuts the axis with specialization, since there are no marginal rates of substitution in production and consumption to equate with specialization.

Into our model with two identical countries let us now introduce trade. First we examine the case where countries specialized in autarky. No trade occurs if the countries specialized in the same direction. If they specialized in opposite directions they can benefit from trade. For example, at the world price ratio coincidental with the straight line joining M and N they are both better off than in autarky. Can one country lose from trade and the other gain? In this situation, unlike certain situations to be developed shortly, we hypothesize a negative answer since there is no market mechanism that would induce a country into trading inadvertently when it would lose from trade. The initial trade offer from autarky indicates whether a country will profit from engaging in trade. After the initial offer, the country will only consider more offers if its welfare position is improved from autarky. Its perception of its welfare position is fixed because its production is fixed.

Now let us introduce trade when both countries are at A in autarky. Initially nothing happens since the price ratios are identical in the two countries. Then in country 2 producers come to market one day with quantities given by A' in Figure 1. Although buyers in country two would have had an excess demand for X_1 in autarky at this new cost ratio, they now turn to country 1 to buy X_1, since at A, country 1 produces X_1 more cheaply. In addition country 1 buyers turn to country 2 to buy X_2 since it is relatively cheaper there. Rather than there being an excess demand for country 2's X_1, there is a world excess supply of it and a world excess demand for that country's X_2. Country 2 moves towards N and country 1 towards M.

The two countries may eventually specialize, improving potential world welfare. That potential world welfare has improved from the autarky positions is obvious, since, given convex transformation curves, the output of both goods has risen, (see Figure 5). Specialization allows for greater exploitations of scale economies in producing a good within a country and hence for the world. However specialization is not guaranteed.

Non-specialization can occur when local stability conditions permit it. For example in Figure 2, country 2 is specialized in X_2 and country 1 is currently in production equilibrium at B. The equilibrium is stable if with a rise [fall] in the price of X_1 the resulting fall [rise] in supply of X_1 is greater than the fall [rise] in global demand for X_1. That is, stability follows if the absolute value of the elasticity of supply of X_1 is greater than the absolute value of the world elasticity of demand for X_1 where both elasticities are negative.

Note that the non-specialized country always loses from trade. Under atomistic competition, the country's producers could not have foreseen this loss from trade when they initially engaged in trade.[4]

What general demand or production conditions would permit an equilibrium such as depicted in Figure 2? Both countries are the same size and were at A in autarky. At B, the relative price of X_1 has declined and the income of the X_1 importing country has risen. Moreover, total world production of X_1 may be less at B than in autarky. In that case X_1 would have to be an inferior consumption good to explain the world fall in demand for N. If world production of X_1 has risen at B, X_1 could be a normal good with a low income elasticity of demand providing the price elasticity demand for real income held constant was negligible.

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4. Compare this with the situation above on pages 5-6. There, countries if specialized in autarky would not trade if trade meant a loss in welfare for either country.

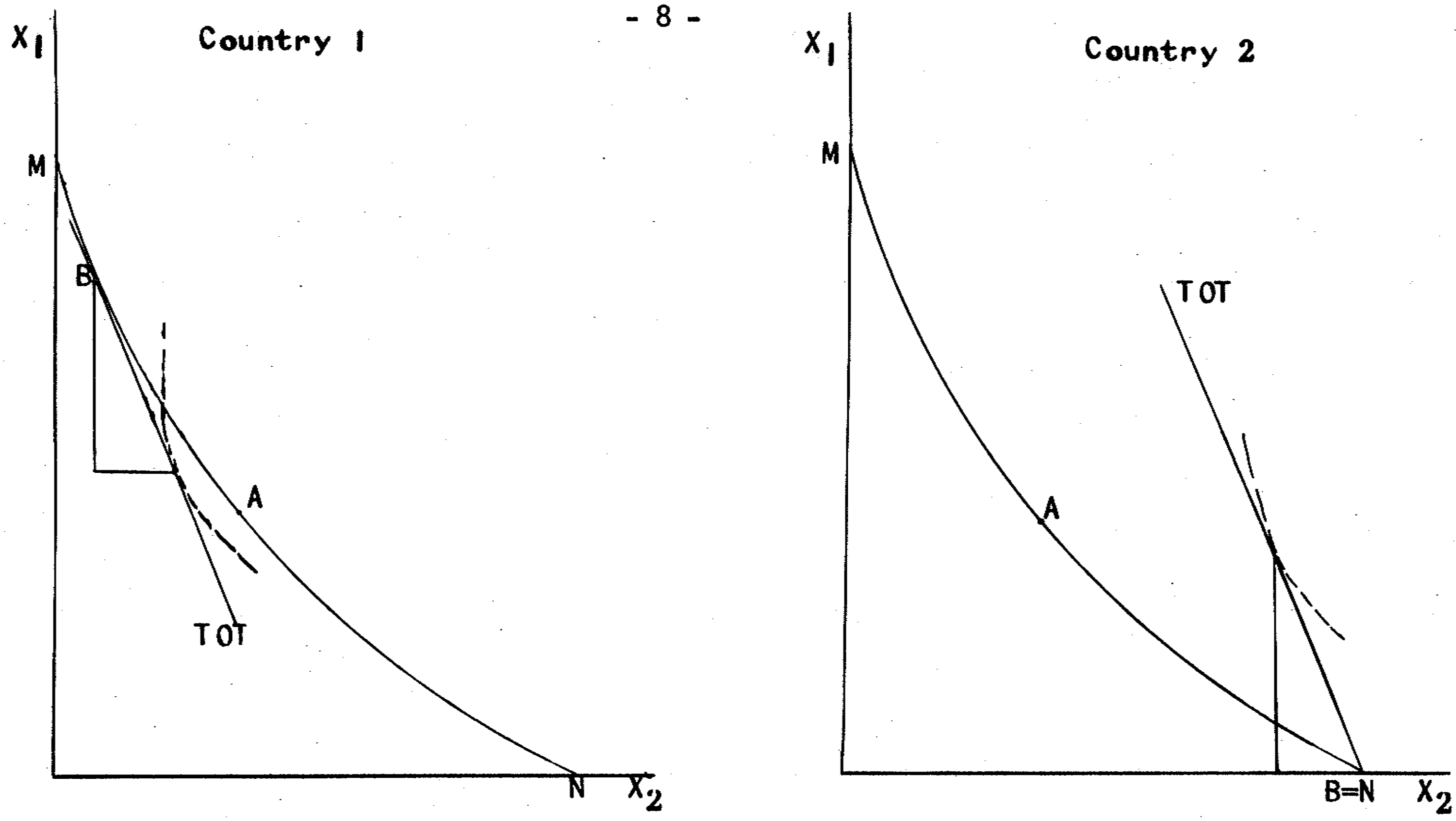

Figure 2

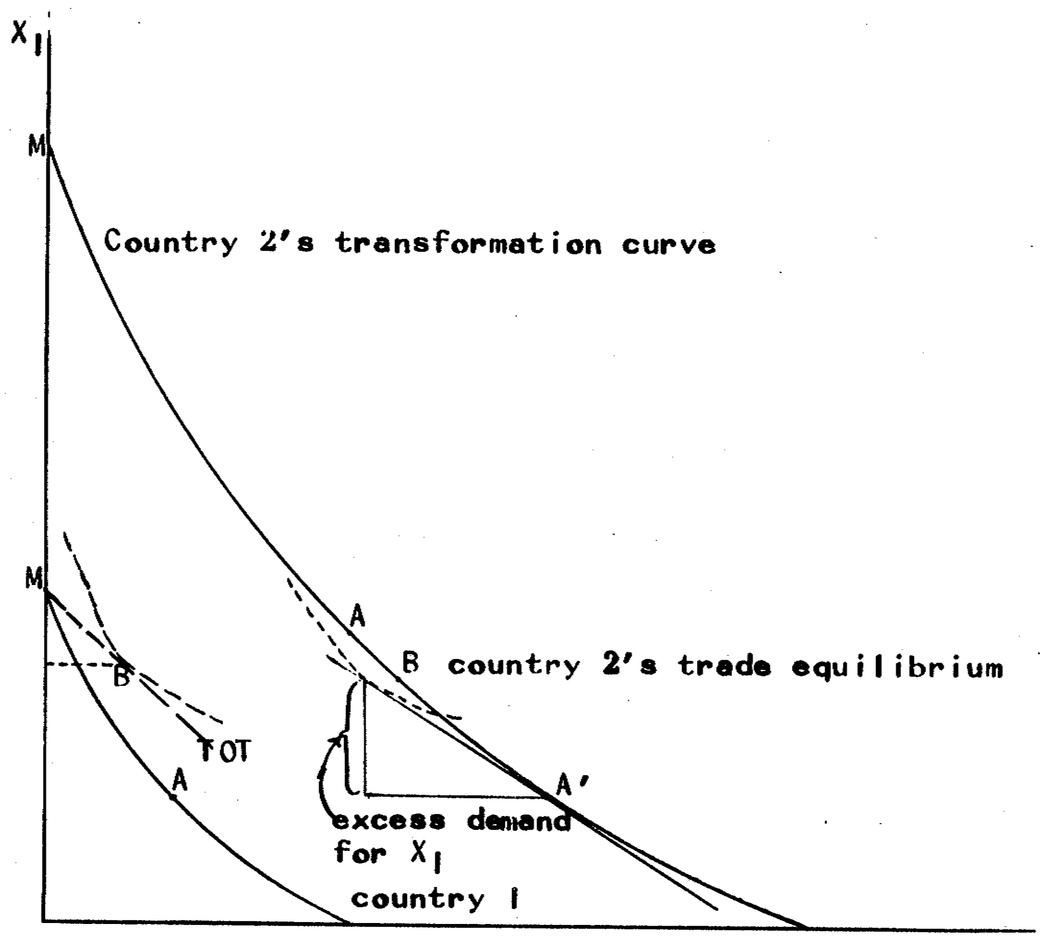

Figure 3

The second reason why one of the two countries may not specialize is due to differences in size, a topic not yet discussed. In Figure 3 we represent both countries in the same diagram, assuming initial closed economy equilibriums at A. After introducing trade, we assume a random movement by producers in country 2 to A'. There is an excess demand for X_1 in country 2. Although country 1 produces X_1 more cheaply, given its own demand it may not even be able to fill the excess demand for X_1 in country 2 (depending on the size of the random movement). However country 1 does move towards M in an attempt to fill this excess demand and eventually specializes in X_1. Country 2 ends up at a point such as B where although it produces more X_2 than in autarky, it still produces some X_1 to satisfy world demand and compete successfully with country 1 producers, who are specialized in the production of X_1 but are operating on a similar scale of industry operation as country 2. Note that the larger non-specialized country loses from trade.

Given globally convex transformation curves, there is no combination of country sizes and income elasticities of demand that will allow both countries to be non-specialized. As we move away from autarky with convex transformation curves, because output responds perversely to price changes, the two countries are moving in directions such that <u>their marginal rates of transformation in production will not converge</u>. Therefore, to equalize price ratios in trade equilibrium, at least one marginal rate of transformation must be eliminated by having specialization.

If we relax the assumption of strong increasing returns to scale in both industries, the transformation curve will be concave over a certain range of production. Combining local concavity with varying country size and income elasticities of demand, we can develop a whole spectrum of trade equilibriums, including non-specialization in both countries. This is possible since, with local concavity in at least one country and hence with output responding normally to price changes, we can achieve equal marginal rates of transformation between the two countries, as we move away from autarky.

This completes our discussion of stable equilibrium in trade. This discussion has isolated what we consider to be the most important concepts involved in determining equilibrium with increasing returns to scale. We now examine the effect upon this equilibrium of having inter-country and intra-country factor mobility.

3. FACTOR MOBILITY AND TRADE EQUILIBRIUM

Inter-Country Factor Mobility. This section will show that if both factors of production are mobile, potential world welfare is improved with factor mobility over and above the gains from trade. Also if both factors are mobile and there is trade, countries will necessarily specialize in a stable equilibrium position. If only one factor is mobile neither of these statements may be true. In addition, mobility of one factor may increase or decrease the inter-country factor price differential that existed for the other factor in autarky.

Starting from the free trade equilibrium we introduce factor mobility into the model. We retain the assumptions of initial equal factor endowments between countries and of globally convex transformation curves. With the introduction of free trade, we assume that countries specialize -- country 1 in the production of X_1 and country 2 in the production of X_2. Since we have specialization, q_1/q_2, the price of X_1 relative to X_2, where q_1 is a numeraire, is determined solely from demand conditions. That is, we have no marginal rates of substitution in production to equate to marginal substitution rates in consumption and hence output does not respond to price changes.

Over all relevant ranges of production, X_1 is labour intensive and X_2 is capital intensive. Factor price ratios for trade equilibrium with specialization are depicted in Figure 4. We utilize <u>total output</u> isoquants so that K_0 and L_0 represent total factor endowments in either country. Equilibrium in both countries occurs at S where

$$(p_L/p_K)_1 > (p_L/p_K)_2$$

p_L and p_K are respectively the wage rate and capital rental. $(p_L)_1$ equals q_1 times the marginal product of labour in the production of $X_1((MP_L)_1)$, $(p_L)_2$ equals q_2 times the marginal product of labour in the production of X_2 $((MP_L)_2)$, and similarly for capital rentals.

Although the price of labour <u>relative</u> to capital is higher in industry and country 1 than in industry and country 2, this does not imply a similar statement about the absolute prices of these factors. In introducing factor mobility, we will assume that factors only move to equalize absolute factor prices or to equalize the purchasing power of factor rewards in the world market. Because the countries specialize and q_1/q_2 is independent of production conditions, this point is crucial. Three situations could prevail at S:

(1) $$(p_L)_1 = q_1(MP_L)_1 > (p_L)_2 = q_2(MP_L)_2 \quad \text{and}$$

$$(p_K)_1 = q_1(MP_K)_1 > (p_K)_2 = q_2(MP_K)_2$$

This situation could only occur if q_2 is small relative to our numeraire, q_1, so that the purchasing power of $(p_K)_2$ is reduced relative to $(p_K)_1$ despite

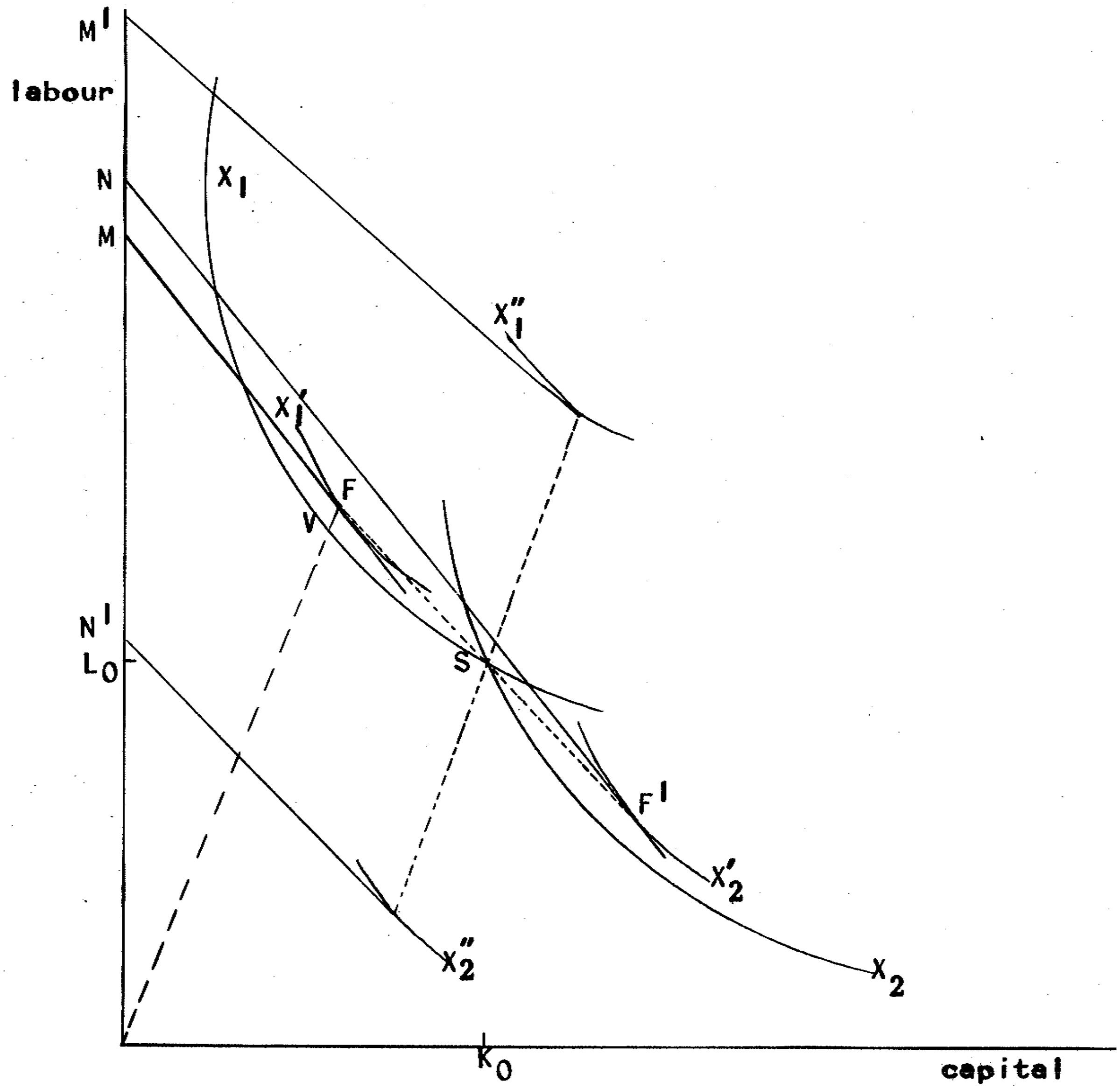

Figure 4

the higher marginal product of capital in country 2.

(2) $(p_L)_1 > (p_L)_2$ and $(p_K)_1 < (p_K)_2$

This is the "normal" case, the case that would be predicted by the relative factor price ratios in the two industries under constant returns to scale and non-specialization.

(3) $(p_L)_1 < (p_L)_2$ and $(p_K)_1 < (p_K)_2$

This is the opposite situation to (1).

a. Both Factors Mobile. From equilibrium at S, let us introduce factor mobility for both factors. Factors move to equalize absolute factor rewards. We will consider the three situations at S, starting with the "normal" case.

(2) $(p_L)_1 > (p_L)_2$ and $(p_K)_1 < (p_K)_2$

Labour moves from country 2 into 1 and capital moves from country 1 into 2.

With the labour inflow into country 1, $(p_L/p_K)_1$ falls. This does not imply that $(p_L)_1$ necessarily falls since we do not know how q_1/q_2 changes from demand conditions and what the quantitative change in $(MP_L)_1$ is, since $(MP_L)_1$ is affected by two things. The fall in the K/L ratio acts to lower it whereas the increase in scale of output acts to raise $(MP_L)_1$.

F and F' are the new unique equilibrium production points where absolute factor rewards are equalized. Also in Figure 4, FS = F'S or factor inflows equal factor outflows for both countries. Note that although at F and F', for reasons to be discussed shortly, absolute factor prices are equalized, these two points are only two of an infinite number of points where relative factor prices are equalized. One could show that on any line through S there will be two points like F where factor inflows equal factor outflows and relative factor prices are equalized. This can be expressed in another way. With the introduction of both factor mobility and free trade, the economic distinction between the two countries disappears. The distinction between the two countries becomes equivalent to the distinction between two industries in a closed economy. In Figure 5, we have a world transformation curve which is the locus of points in output space where relative factor prices are equalized. We have a world efficiency locus which defines all these points in the above paragraph where relative factor prices are equalized. Given our initial assumptions with respect to tastes and indifference curves, there is a world indifference curve uniquely tangent to this transformation curve. This tangency assures equilibrium in both factor and goods markets.

This tangency in Figure 5 corresponds to points F and F' in Figure 4 where absolute factor prices are equalized. When absolute factor prices are equalized by definition, not only are relative factor prices equalized but so is the purchasing power of factor payments in the two countries.

Furthermore, absolute factor price equalization, as in a unit cost Lerner-Pearce diagram, implies that the market price of both goods uniquely equals the unit costs of production of X_1 and X_2 as expressed in terms of one or the other factors. In terms of Figure 4 using labour as the unit of measurement, this implies that

$$\frac{q_1}{q_2} = \frac{OM/X_1'}{ON/X_2'}$$

Deflation by X_1' and X_2' is possible due to the assumption of homotheticity of the isoquants and serves to reduce OM and ON to the unit costs of production

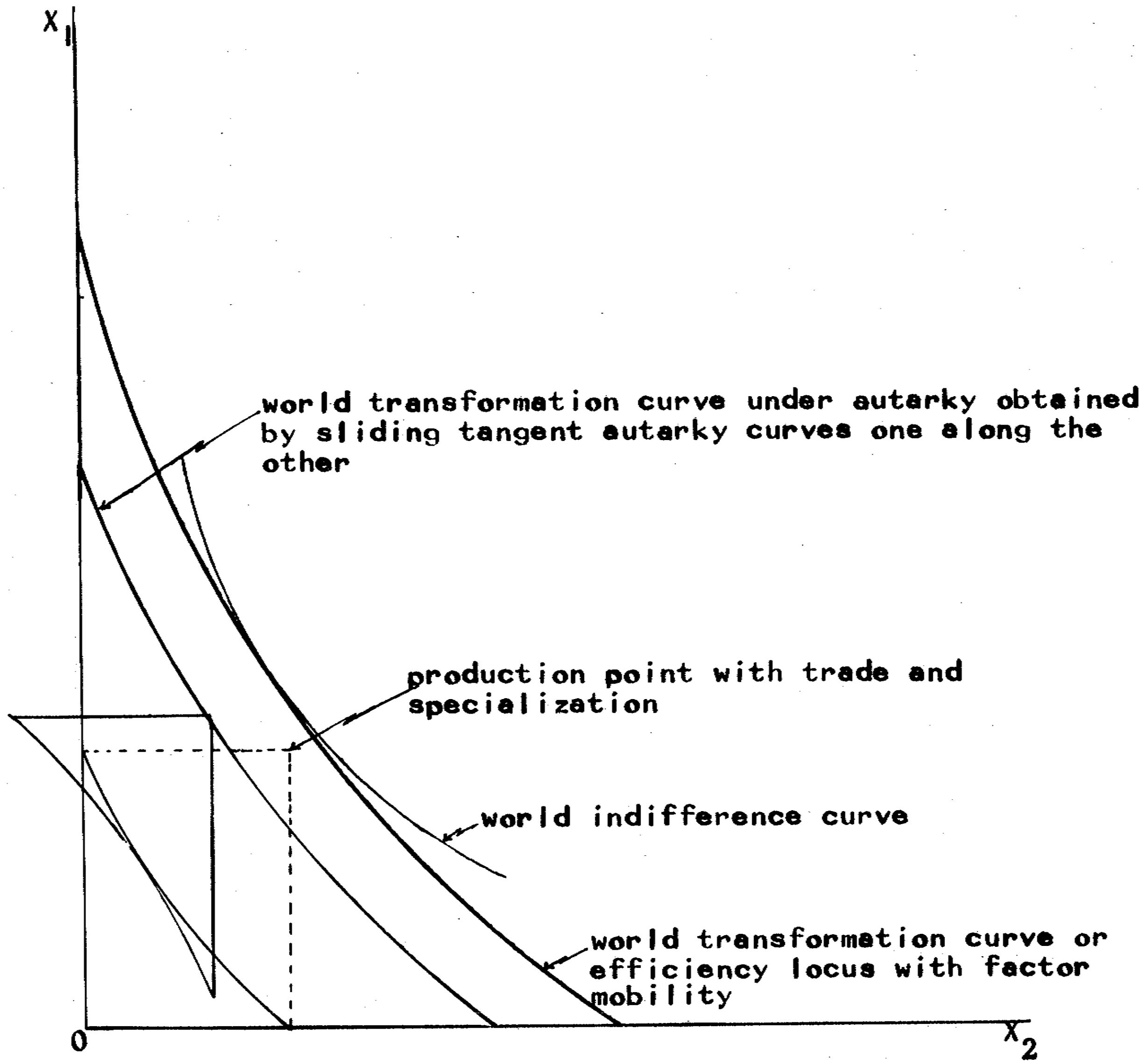
X_1
world transformation curve under autarky obtained by sliding tangent autarky curves one along the other
production point with trade and specialization
world indifference curve
world transformation curve or efficiency locus with factor mobility
0
X_2

Figure 5

in equilibrium. Deflation is necessary because of increasing returns to scale; i.e., output increases by more than OF/OV, where the shift in the isoquant is limited by absolute factor endowments.

A final important comment on our new equilibrium is that potential world welfare or the income of all factors with redistribution has risen. From Figure 4 this is clear since output of both goods has risen. Thus there are gains from <u>both</u> factor mobility and free trade.[5]

We will now examine the effects of factor mobility upon equilibrium if the "non-normal" cases prevail.

(1) $(p_L)_1 > (p_L)_2$ and $(p_K)_1 > (p_K)_2$

Both capital and labour flow from country 2 into country 1 resulting in a fall in the output of X_2 and a rise in the output of X_1. Equilibrium is achieved with either a reduced output of X_2 or a zero output of X_2. The scale effect of reduced output will probably reduce the marginal products of both factors in industry 2; a change in the K/L ratio will benefit one factor relative to the other however. Similarly in country 1 the marginal products of both factors probably rise. Thus equilibrium can only be achieved with a fall in the q_1/q_2 ratio as the output of X_2 falls. In equilibrium in Figure 4 this implies that

$$\frac{q_1}{q_2} = \frac{OM'/X_1''}{ON'/X_2''}$$

If q_1/q_2 does not fall far enough to equate absolute factor prices

5. Melvin (1969) has made this point. The rest of his discussion on factor mobility is incorrect; this is pointed out in Henderson (1972a).

in the two countries, then the output of X_2 must go to zero.[6] By reference to Figure 5, one can see that this would imply that the world indifference curve cuts the world transformation curve at the X_1 axis and that this transformation curve has a greater degree of curvature than the indifference curves. This could imply that there was specialization in autarky but does not necessarily do so. If community indifference curves are homothetic (hence equal-sloped at the X axis) and if R is constant or changes slowly so that the transformation curve will have <u>more curvature</u> (greater negative slope) at the X axis <u>as we move out the axis</u>[7], then we could have world specialization with factor mobility but non-specialization in autarky. However specialization in autarky implies world specialization with factor mobility, regardless of what happens (see p. 5) with free trade and no factor mobility.

(3) $(p_L)_1 < (p_L)_2$ and $(p_K)_1 < (p_K)_2$

This is the reverse case to one. The results are the same except that country 2 now receives the factor flows and X_2 rises.

Suppose that a country was non-specialized before factor mobility. Would the introduction of factor mobility provide for a stable equilibrium with non-specialization. The first result that comes to mind is that, regardless of the shape of the transformation curve, we are better off with countries specializing. This follows from the nature of scale economies

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6. There appears to be no reason why in final equilibrium this situation could not prevail for case 2. Some set of demand conditions and factor flow paths (where the initial direction of factor flows for one factor is different from the final direction) would yield zero output of X_2 (or X_1).

7. See Herberg and Kemp (1969), pp. 406-408 for a proof of the fact that the slope of the transformation curve increases negatively as we move out the X_1 axis holding R_1 constant.

which are internal to a country and an industry. Concentrating production in one country of a good concentrates the exploitation of scale economies.

There are only two possible positions in trade with non-specialization that will equalize absolute factor rewards. We only consider cases where stability prevails in output markets. Further we hypothesize that our two positions are both unstable from a market point of view.

Our first position where absolute factor prices are equalized has both countries non-specialized with locally concave transformation curves (for output market stability) and of identical size and output combinations. If this latter condition does not prevail, factor price equalization is impossible.[8] Unlike constant returns to scale, with increasing returns to scale, two items define factor prices -- K/L ratios and scale of output. Unless these are identical there can be no equalization.

Moreover we hypothesize that even this one position of factor price equalization is unstable. If a unit of capital and labour randomly move from industry 1 in country 1 to industry 1 in country 2 (say the K/L ratio in industry 1 is currently one) then capital and labour earn a higher return in country 2's industry 1 relative to country 1, regardless of what happens to q_1/q_2, because of the rise in the output of X_1 in country 2. This will induce further factor flows; i.e. the initial equilibrium is unstable.

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8. This can be shown rigorously in a Jones (1965) model. In Jones (1968) from equations (7') and (8') we know

$$\theta_{LX_1} p_L^* + \theta_{KX_1} p_K^* = q_1^* + R\, X_1^* \qquad (7')$$

$$\theta_{LX_2} p_L^* + \theta_{KX_2} p_K^* = q_2^* + R\, X_2^* \qquad (8')$$

where θ_{ij} is the share of the i^{th} factor in the value of output of the j^{th} good, R is the degree of increasing returns to scale, and the asterisk refer to rates of change. If $p_L^* = p_K^* = q_1^* = q_2^* = 0$ due to factor and output price equalization from mobility and trade between two countries then $X_1^* = X_2^* = 0$. The countries must be identical.

The second position of initially equal factor rewards occurs in a situation such as depicted in Figure 3 where the countries are of different sizes and one country is specialized. In equilibrium, the good produced in both countries would have to have equal K/L ratios and the same level of output. However a random factor movement would be unstable; this can be illustrated by using the same example as cited for the first case.

Both positions of non-specialization in trade and absolute factor price equalization are unstable. Thus in equilibrium with factor prices equalized and with free trade, both countries must be specialized.

One Factor Mobile. We will now examine the effects of factor mobility when only one factor is mobile. We choose capital to be mobile. At S in Figure 4, three situations could initially prevail, as before, in free trade equilibrium. We examine these three cases.

(2) $(p_L)_1 > (p_L)_2$ and $(p_K)_1 < (p_K)_2$

Country 2 receives capital from country 1. In Figure 6, we move to an X_2 isoquant further out a horizontal line through S and, either to an X_1 isoquant further back along the horizontal line, or, to zero output of X_1 if $(p_K)_1$ remains always less than $(p_K)_2$. If $X_1 > 0$ in the new equilibrium, $(p_K)_1 = (p_K)_2$; and q_1/q_2 should have risen since the output of X_2 has risen. The effect on relative wage rates between the two countries is uncertain. As capital moves into country 2, the marginal product of labour rises due to the K/L ratio and scale effects. However the price of X_2 relative to our numeraire falls. In country 1, the opposite forces are at work. If we presume that the marginal product effect on wages outweighs the output price effect and thus $(p_L)_1/(p_L)_2$ falls, we do not know if it falls sufficiently to overcome the initial wage differential between the two countries.

Note that having only one factor mobile implies a loss in world welfare since we are not on the world efficiency locus. In equilibrium in Figure 4, this would means that the slopes of the isoquants at the production points in the two countries are not equal and hence we are interior to the world efficiency locus. As in Haberler's (1950) discussion of factor immobility between constant returns to scale industries within a country, it is not certain that we benefit from mobility of one factor. Trade equilibriums with one and zero mobile factors involve a comparison of two inefficient points.

This last point can be illustrated with a trivial example. Country 1 specializes in X_1 and country 2 in X_2 with the following production functions:

$$X_1^{1-1/6} = L_1^{2/3} K_1^{1/3} \quad \text{and} \quad X_2^{1-1/6} = L_2^{1/3} K_2^{2/3}$$

where $X_i = 0$ if $L_i, K_i = 0$.

Both countries are endowed with a hundred units of capital and labour. The two goods are perfect substitutions in consumption so that nothing happens when we introduce trade; there are no gains from exchange. Now introduce capital mobility and all capital will flow from country 1 into country 2. Total output and hence value of total output falls since now $X_1 = 0$ and $X_2 = 2^{4/5}\ 100^{6/5}$ whereas before $X_1 + X_2 = 2.100^{6/5}$. There is a loss in world welfare with the introduction of mobility of one factor.

We now move on to consider the first and third cases.

(1) $(p_L)_1 > (p_L)_2$ and $(p_K)_1 > (p_K)_2$

Capital moves from country 2 into country 1 and the output of X_1 rises and X_2 falls. In equilibrium, with equalized capital rentals, the effect on wage rates is uncertain but one would presume that $(p_L)_1$ was still greater than $(p_L)_2$. The movement of capital into X_1 will raise $(MP_L)_1$ and decrease $(MP_L)_2$. Although q_1/q_2 probably falls, it should not fall enough to overcome the effect on the absolute wage differential of the two industries of the rise in the $(MP_L)_1$, the fall in the $(MP_L)_2$, and the initial wage differential.

Note that there exists a possibility of all capital leaving country 2 if $(p_K)_2$ never rises enough to meet the falling $(p_K)_1$. The movement of capital into country 1 affects the $(MP_K)_1$ in two opposite ways. The K/L ratio effect works to lower the $(MP_K)_1$ and the scale effect works to raise it. Even if the K/L ratio effect did outweigh the scale effect and given q_1/q_2 falls, we do not know if these effects are large enough to eradicate the initial capital rental differential. If all capital leaves the country, labour there becomes unemployed.

(3) $(p_L)_1 < (p_L)_2$ and $(p_K)_1 < (p_K)_2$

For this case of capital flowing from country 1 into 2, similar reasoning is used as in the above, reverse, case. If, as seems likely, capital rentals are equalized between the two countries before X_1 ceases to be produced, then we presume that $(p_L)_1$ remains less than $(p_L)_2$.

As in the case of two mobile factors, do we assert that, regardless of whether trade equilibrium involved non-specialization by one or two (for local concavity of the transformation curve) countries, equilibrium with trade and one mobile factor will involve specialization by both countries?

If only one factor is mobile we can no longer assert that specialization will occur. First the number of situations where we can have non-specialization and absolute factor price equalization for one factor has increased. The marginal products between two countries for the same industry can be equalized for capital without having the same level of output in the two countries and the same K/L ratio (i.e., we do not need to also equalize wage rates). Secondly our stability arguments are changed. We can only allow random movements of just capital. If we move a unit of capital from industry 1 in country 1 to industry 1 in country 2, the rental rate of capital in industry 1 in country 2 will only rise relative to country 1 to create further factor flows from an initial equilibrium position if the positive scale effect outweighs the negative K/L effect, an uncertain happening.

This discussion of inter-country factor mobility has been carried out under the hypothesis that factors move to equalize their purchasing power between countries. In all cases, the equilibrium attained was unique. For the case of two mobile factors we operated on a world efficiency locus where in equilibrium there were distinct gains from both trade and factor mobility. If we have trade and mobility of only one factor it is not certain that we benefit from factor mobility; we are essentially comparing two points of the world efficiency locus, trade equilibrium with and without mobility of one factor.

With either one or two factors mobile it is possible that the world will specialize in the production of just one good, regardless of whether there was specialization in autarky. If only one factor is mobile this would mean that the immobile factor would become unemployed in one country.

Intra-Country Factor Mobility. The discussion of intra-country or regional factor mobility involves the concepts developed above. With a fixed output price or small country assumption, the discussion becomes both simpler and more easily identifiable with current economic problems. Our focus will be on regional unemployment and the role of increasing returns to scale regionally versus internationally.

We will first examine the effect of increasing returns to scale upon the internal organization of an industry when both factors are mobile within a country. If economies of scale are location specific we would expect all production of a good to occur at one point. By location specific, we mean that all production must occur in, say, one city to exploit the scale economies of developed labour markets or the provision of industry fixed capital costs for items such as transportation networks that all firms use commonly. Production occurs at one point to concentrate the exploitation of scale economies and to reduce the input-output coefficients as far as possible. This concentration may be limited.

First we may exhaust scale economies of one location and R_i might become negative. Then at some point it would become advantageous to split into two locations. Even if R_i remains positive, as production rises <u>other</u> economic activity may suffer inefficiencies from the concentration of this industry. For example workers must be housed near the production sites and must commute to work. As concentration increases and commuting distance rises, residential location theory tells us that the costs of housing and commuting rise.[9] At some point workers would be better off locating at a new industry production location.

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9. See Mills (1967).

This latter concept is important. We may have efficient size production units called cities where economies of scale are effectively exhausted. If we start initially with one city in the economy and expand output, eventually it will pay to split into two cities and then into three and four cities and so on as scale economies are exhausted in each city. If this is so, in a large economy from a national perspective, if we were to double factor endowments we would simply double cities and output. This is in spite of the fact that regionally or in each city, our industry production functions may be characterized by an assortment of scale (dis)economies.[10]

Concentration of production is also affected by the degree of factor mobility. Suppose we start with one industry located in two different regions between which factors are immobile. The regions have the same factor endowment ratios but one region is smaller. Capital and financial markets in the country develop and capital becomes mobile. Capital flows from the small region into the large region until either capital rentals are equalized or output of the small region falls to zero. In the latter case unemployment results and in the former the wage rate of the small region falls relative to the large industry.

We will now examine the situation of two different industries in two different locations within a small country. When we introduce capital mobility into the current equilibrium the same situation results as in the above paragraph. Capital flows into the region with the higher real return to capital until either the returns are equalized or all capital leaves one region. Once again the region losing capital experiences a fall in its wage

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10. See Henderson (1972b) for a rigorous development of these arguments.

rate or unemployment results if all production of the region's good ceases.

This same situation of either regional wage differentials or equilibrium regional unemployment can be derived from other circunstances involving two different industries in different locations when capital is mobile. Into an initial equilibrium with capital rentals equalized between industries, introduce a rise in the price of one of the goods or a technological improvement in the production of one of the goods. The industry benefiting from the price rise or technological improvement experiences capital inflows which will only be halted when capital rentals are once again equalized or there is no capital left in the other region.

In all of these situations there is no implication that factor mobility of just one factor must result in an improved potential welfare position for the country over the case of zero mobile factors. Once again we are just comparing two inefficient equilibrium positions.

4. THE THEOREMS OF THE HECKSCHER-OHLIN MODEL

Are the Stolper-Samuelson and Rybczynski theorems affected by increasing returns to scale in production? The theorems may or may not hold; and if they do hold, the magnitudes involved change from the case of constant returns to scale. The theorems have been discussed algebraically in full by Jones (1968) and Kemp (1969). Thus our presentation will stress the economic and geometric interpretation of the results.

We assume that the economy is engaged in trade and produces an import and export good using two factors of production. Both goods are produced under increasing returns to scale. It is assumed that R_i, the degree of increasing returns to scale, is less than one or, in other words, that although average costs of production fall with increasing output, total costs always rise.

We also assume for almost all of this discussion that scale economies are Hick's neutral or production functions are homothetic. If Hick's neutrality prevails, then the qualitative validity of the theorems in question is dependent on the shape of the transformation curve under one provision. The provision is that the shape of the transformation curve can be inferred from the direction of output changes in responses to market price changes, which is true if dR_i/dX_i is zero or small.[11] If, as under constant returns to scale, output of a good responds positively [negatively] to a price increase, then the transformation curve is locally concave [convex]. A discussion of the transformation curve will clarify these points and will lead directly to an understanding of the validity of the two theorems.

Under constant returns to scale the concavity of the transformation curve results from factor substitution in production and a diminishing marginal rate of transformation between the two outputs. If X_1 is L-intensive and X_2 K-intensive, as the output of X_1 rises the K/L ratio in both industries rises, raising both the cost of X_1 relative to X_2 and the wage rate relative to the capital rental rate. With increasing returns to scale this relationship prevails under local concavity. However increasing returns to scale generates another effect on cost besides factor substitution and that is a scale effect which serves to reduce cost as output rises. Under local convexity of the transformation curve, although factor substitution occurs and

11. See Herberg and Kemp (1969), pp. 409-413, for an analysis of this point. Note we are only discussing local curvature properties of the transformation curve since we are only rigorously examining small movements about an initial equilibrium position.

as X_1 rises, the $(MP_L)/(MP_K)$ rises, the cost of producing X_1 relative to X_2 falls due to the scale effect. Thus with local convexity the constant returns to scale relationship between the relative costs of production of the two goods and both relative factor prices and relative levels of final good output is reversed.

Turning to the Stolper-Samuelson theorem, what happens to relative factor prices if the relative price of a good increases exogenously (due to a tariff, for example)? Under local concavity, output of a good responds positively to its price rise and the relative price of the factor used intensively in that good rises. Under convexity, output responds perversely to a price increase; and the perverse response of output leads to a fall in the production of the good whose price (but not output) has risen. The Stolper-Samuelson theorem fails to hold. This is illustrated in Figure 6 using unit isoquants.

Two comments are in order re the inapplicability of the Stolper-Samuelson theorem under local convexity. First if the transformation curve is locally convex, we would first have to determine whether the country could attain a stable equilibrium of non-specialization rather than an equilibrium of specialization or an equilibrium of non-specialization on a locally concave part of the transformation curve. Then, with a price change, we would have to determine if the new price ratio could be attained at a stable point of non-specialization. If the new non-specialization point was unstable, then the resulting specialization would change our quantitative, but not qualitative results. Secondly, if economies of scale are not Hick's neutral, then marginal factor intensities of goods may differ from average factor intensities. For example at the current level of output, R_i could act only

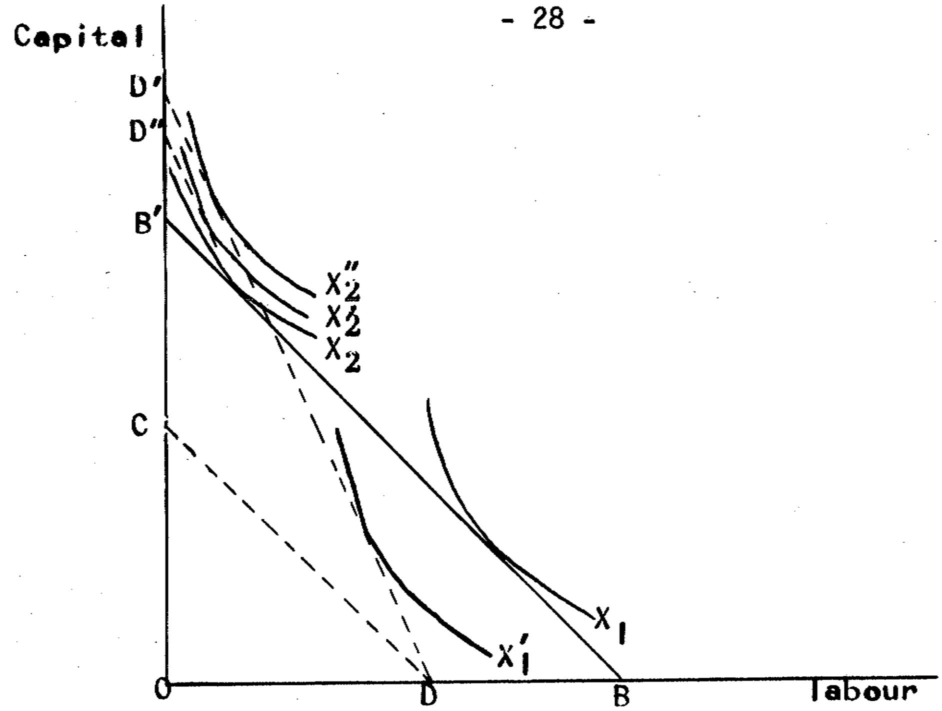

Figure 6

The initial situation is the factor price line B′B and the X_1 and X_2 isoquants. For our experiment, we increase the output of X_1, shifting the X_1 isoquant back to X_1' and increasing the relative wage. Then to see whether the Stolper-Samuelson theorem holds, we see if this increase in output was <u>initiated</u> by a <u>rise or fall</u> in q_1/q_2. If X_2 shifts to X_2', q_1/q_2 rises by OD′/OD″ and the theorem holds since relative wages have risen (i.e., OD′/OC>OD′/OD″). If X_2 shifts beyond X_2'', then q_1/q_2 <u>falls</u> in order for the increase in X_1 to occur. The theorem does not hold.

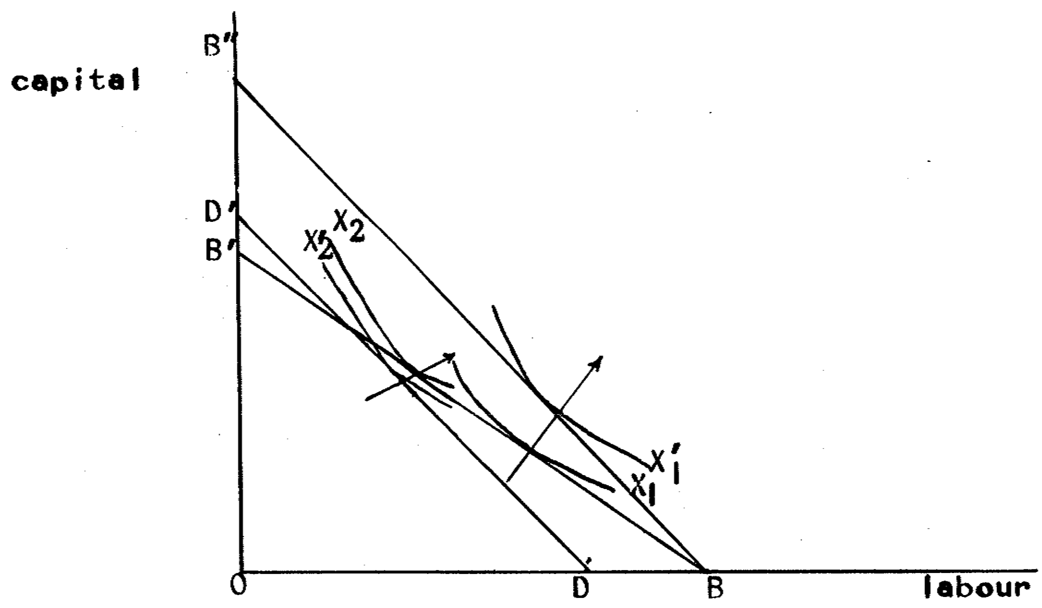

Figure 7

The initial situation is the same as in Figure 6, except that we assume initially that the transformation curve is convex. Thus when we increase q_1/q_2, X_1 falls due to the curvature of the transformation curve. This results in a shift of X_1 to X_1' and of X_2 to X_2' and the rise of q_1/q_2 to OB″/OD′. The arrows indicate marginal factor intensity different from average factor intensity. Thus relative wages rise or OB″/OB′ > OB″/OD′. The theorem holds.

on the factor used, on average, intensively. Then, if the price of a good rises, even with local convexity and falling output of the good, it is the price of the factor used intensively at the margin that falls; and thus the price of the factor of average intensity rises. This is demonstrated in Figure 7.

The Rybczynski theorem examines the effect of an increase in the supply of a factor upon the output of the good using that factor intensively. If the experiment is carried out for <u>relative</u> factor prices held constant, then the K/L ratio in the two industries must be maintained to hold relative factor prices constant. K/L can only remain constant if the output of the good using the increased factor intensively rises. The theorem holds independently of the shape of the transformation curve.

However, suppose for the experiment we hold commodity prices constant. Then we increase K, the factor used intensively in the production of X_2. To maintain commodity prices, since the economy K/L ratio has risen and the relative opportunity cost of X_2 fallen, we must increase the relative cost of producing X_2. <u>With a locally concave transformation curve</u>, this is accomplished through factor substitution and a rise in the output of X_2 until, either, under constant returns to scale, the initial K/L ratios in the two industries are achieved again, or, under increasing returns to scale, the K/L ratios in the two industries have fallen from the initial level to offset any adverse scale effects on costs as output of X increases. However under local convexity, one will recall that the scale effects on cost outweigh the factor substitution effects and cost falls as output of an industry increases. Thus to maintain commodity prices the Rybczynski theorem is reversed and output of the good using the increased factor intensively falls. This is illustrated in Figure 8.

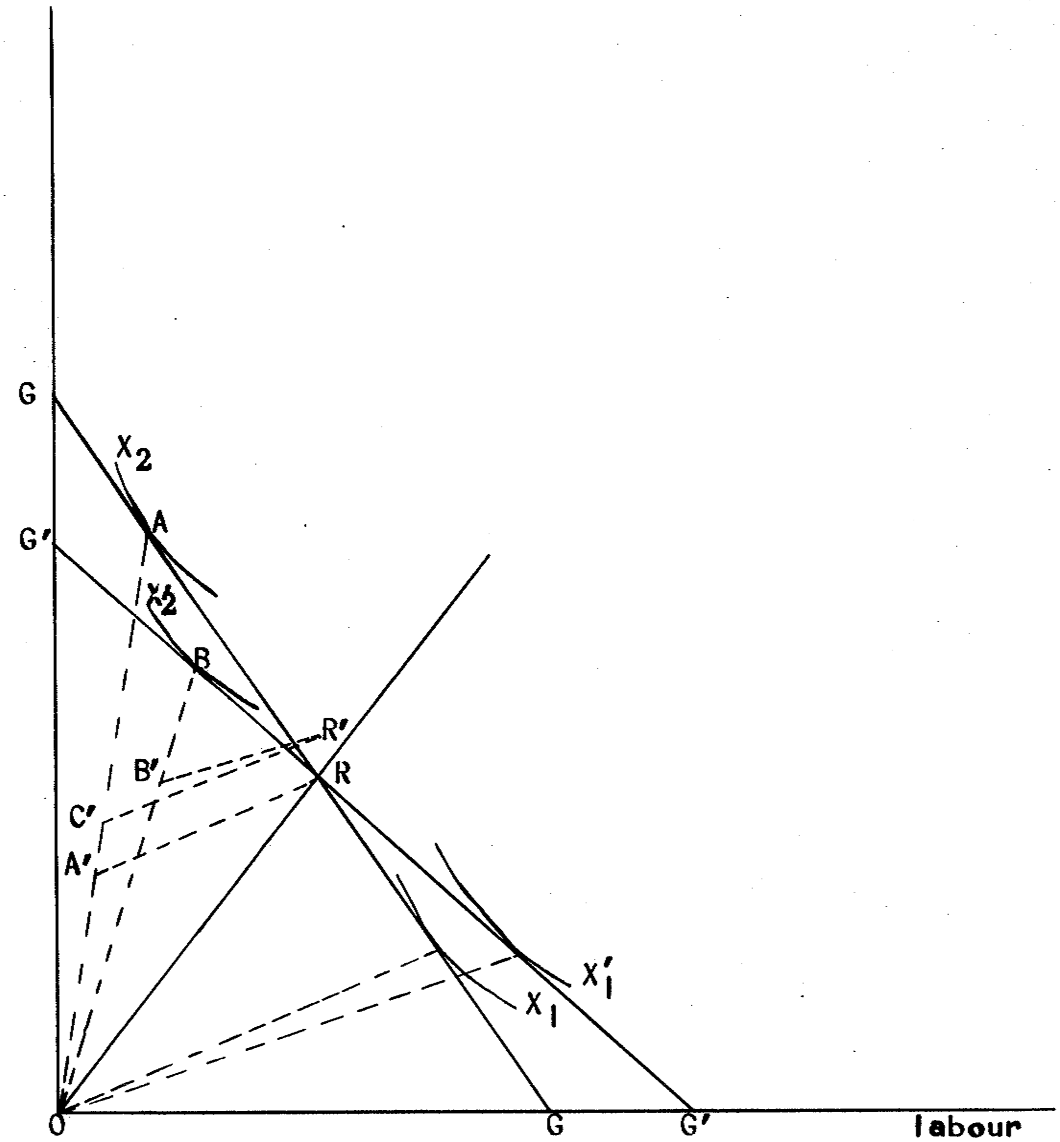

Figure 8

The initial price line is GG. Increase the endowment of K to R′ from R. Production of X_2 rises and the relative wage rate falls. X_2 as a percentage of output rises from OA′/OA to OB′/OB, more than the rise then if there were constant returns to scale (where the rise would be to OC′/OA). If the theorem does not hold, the diagram would have to be redrawn with the reverse change in outputs. An indication of the theorem not holding in this diagram would be a contradiction such as X_1 falling and X_2 rising so much that B′ lies beyond B or that X_2 is more than 100% of total output.

5. CONCLUSIONS

Increasing returns to scale are an important determinant of trade. In examining trade equilibrium special attention must be paid to stability conditions. If transformation curves are globally convex one could expect specialization in trade. Non-specialization in trade is possible if one of the two goods is an inferior good in consumption or the two trading partners vary greatly in size. The non-specialized country in these cases loses from trade.

In addition to the gains from trade due to scale economies, there are gains from factor mobility when both factors move between countries to equalize absolute factor rewards. If both factors are mobile the countries will always specialize in production. If only one factor is mobile, gains from mobility and complete specialization by both countries are not assured. Also mobility of only one factor can result in country's production ceasing. The principles of factor mobility between countries can be applied to an analysis of intra-country factor mobility and regional unemployment.

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