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TRADE, ACCUMULATION, AND UNEVEN DEVELOPMENT

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Introducation

Why is the world divided into rich and poor nations? Most radical critics of the international economic order would argue that there is some fundamental unequalizing process at work. The argument that there is an inherent tendency for international inequality to increase is often referred to as the doctrine of "uneven development." This doctrine is usually associated with marxists such as Baran (1951), Frank (1967), and Wallerstein (1974), but similar arguments have also been made by nonmarxists such as Myrdal (1957) and Lewis (1977).

This paper sets out a model which attempts to present the essentials of the doctrine of uneven development in schematic form. The model portrays a two-region world in which the industrial sectors of regions grow through the accumulation of capital. Given one crucial assumption--that there are external economies in the industrial sector--a small "head start" for one region will cumulate over time, with exports of manufactures from the leading region crowding out the industrial sector of the lagging region. This process, I would argue, captures the essence of the argument that trade with developed nations prevents industrialization in less-developed countries.

In addition to helping synthesize and clarify the arguments of theorists of uneven development, the model set forth in this paper is of some technical interest. Conventional trade theory has often been criticized for being static and for assuming constant returns to scale. The model developed here meets these objections, while continuing to make use of the tools of orthodox theory. One of the surprising things that emerges from the analysis is that the marxist theory of uneven development fits in very well with the Heckscher-Ohlin theory of trade.

The paper is organized in four sections. Section 1 lays out the structure of the model. The basic analysis of the model's dynamics is carried out in

This paper was stimulated by discussions with Lance Taylor.

Section 2. Section 3 considers the role of international investment, and shows that the model naturally gives use to a two-stage pattern of development which bears a striking resemblance to Lenin's theory of imperialism. Finally, Section 4 extends the analysis to a thre-region world.

1. The Basic Model

Consider a world consisting of two regions, North and South. These regions will be assumed to be identical in the sense that technological and behavioral relationships are the same. To sharpen the analysis, I will also assume that the regions have equal labor forces, and that these labor forces do not grow over time. Thus we have

$$L_N = L_S = \bar{L} \tag{1}$$

Each region will be able to produce two goods, a manufactured good M and an agricultural product A, and to trade at zero transportation costs. There will thus be a single world price of manufactured goods in terms of agricultural products, P_M. Agricultural products will be produced by labor alone; we will choose units so that one unit of labor produces one unit of agricultural goods.

The growth sector, however, is manufacturing. Manufacturing will require both capital and labor. It will be assumed that, from the point of view of an individual firm, the unit capital and labor requirements are fixed.[1/] In the aggregate, however, unit capital and labor requirements will not be constant; instead, in each region they will be decreasing functions of the region's aggregate capital stock. Letting c_N, c_S, v_N, v_S be the unit capital and labor requirements in North and South respectively, we have

$$c_N = c(K_N) \qquad (2)$$

$$c_S = c(K_S)$$

$$v_N = v(K_N)$$

$$v_S = v(K_S)$$

where $c', v' < 0$. I will, however, assume that the absolute value of the elasticity of unit input requirements with respect to output is less than one, so that <u>total</u> input requirements rise as manufacturing output rises.

Since the assumption of external economies in the industrial sector is crucial to the dynamic story we are about to tell, it requires some discussion. There are really two questions here. First, can external economies be justified in microeconomic terms? Second, does the concept of external economies really capture the processes theorists of uneven development have in mind?

The justifications for technological externalities have, of course, been familiar since Marshall. Even if economies of scale are internal to firms, internal economies in the production of intermediate inputs can behave

like external economies for the firms which buy them. So it is certainly legitimate to make use of the concept. What may be questioned is whether external economies are empirically important or, if they are, whether they are more important in manufacturing than in agriculture. For the sake of argument this paper will assume that there are important external economies specific to the industrial sector.

From a doctrinal point of view it also seems reasonable to use external economies as a key element in a theory of uneven development. Some theorists of uneven development, such as Baran (1957), have explicitly stressed the role of external economies. More generally, the essential argument in any theory of an unequalizing spiral must be that a region with already developed industry has an advantage in industrial production over a region without, and it is hard to see how to model this except in terms of external economies.[2/] While many authors have also argued for other factors, such as a distorting effect of the interaction with developed countries on demand in less-developed countries, external economies seems to be a useful minimal assumption.

Given the relationships (2), then, together with full employment of factors, we can determine the pattern of output. In each country the output of manufactured goods depends on the capital stock:

$$M_N = K_N/c(K_N) \qquad (3)$$

$$M_S = K_S/c(K_S)$$

Output of agricultural goods can then be determined from the agricultural sector's role as a residual claimant on labor:

$$A_N = \bar{L} - v_N M_N \qquad (4)$$

$$A_S = \bar{L} - v_S M_S$$

Note that there is an upper limit, K_{max} to the amount of capital which can usefully be employed in either region, which comes when the region is completely specialized in manufacturing and no more labor can be drawn out of agriculture. We can define K_{max} by noting that $v(K_{max}) \cdot K_{max}/c(K_{max}) = \bar{L}$.

Consider next the distribution of income. There are two cases: the case in which at least some labor is used in agricultural production, and the case of complete specialization in manufacturing. If some labor is used in agriculture, this ties down the wage rate, which is 1 in terms of agricultural goods, $1/P_M$ in terms of manufactures. We can then determine the rental per unit of capital as a residual. For simplicity, let us assume (though it is not essential) that capital goods are produced by labor alone, i.e., we include them as part of "agricultural" output. Then the rental per unit of capital, measured in agricultural (or wage) units, is also the profit rate, and we have

$$\rho_N = (P_M - v_N)/c_N \tag{5}$$

$$\rho_S = (P_M - v_S)/c_S$$

where ρ_N, ρ_S are profit rates North and South. Since c and v are functions of the capital stocks, we can also write (5) as a pair of reduced form equations

$$\rho_N = \rho(P_M, K_N) \tag{6}$$

$$\rho_S = \rho(P_M, K_S)$$

where $\partial\rho/\partial P_M$ and $\partial\rho/\partial K$ are both positive.

When a region is completely specialized in manufacturing, (6) no longer holds. Instead the rate of profit is determined in Kaldorian fashion by the requirement that savings equal zero, if there is no foreign investment, or by the rate of profit on foreign investment if there is such investment.

In the latter case the wage rate is residually determined.

To close the model we need to specify the demand side. I will make two strong assumptions for the sake of easy algebra; the conclusions of the model could be derived under weaker but less convenient assumptions. First, saving behavior is classical: all profits and only profits are saved. Second, a fixed proportion μ of wages will be spent on manufactures, $1-\mu$ on agricultural goods.

The savings assumption means that, if there is no international investment, the rate of growth of the capital stock in each region will just equal the rate of profit

$$\dot{K}_N/K_N = \rho_N \tag{7}$$

$$\dot{K}_S/K_S = \rho_S$$

It is easy to see how this can give rise to an unequalizing spiral. Suppose we are at any early stage in the development of the world economy where both regions are nonspecialized, but North has accumulated more capital than South. Then since the regions will face a common relative price of manufactures, by (6) the rate of profit and the rate of growth will be larger in the region which already has more capital. This is the basis for the divergence analyzed in more detail below.

The relative price of manufactured goods will be determined by world demand and supply. Since a fraction μ of wages is spent on manufactures, provided that both countries produce some agricultural goods we have

$$P_M[M_N + M_S] = \mu[L_N + L_S] \tag{8}$$

which can be rewritten as

$$P_M = 2\mu\bar{L}/[K_N/c(K_N) + K_S/c(K_S)] \tag{9}$$

This gives us a relationship between the two capital stocks and P_M; it is apparent that P_M is decreasing in both capital stocks. Note also that K_N and K_S enter symmetrically, so that where $K_N = K_S$, $\partial P_M/\partial K_N = \partial P_M/\partial K_S$.

Finally, we can combine (6), (7), and (9) to express the rate of change each region's capital stock as a function of the levels of both capital stocks:

$$\dot{K}_N/K_N = g(K_N, K_S) \tag{10}$$

$$\dot{K}_S/K_S = g(K_S, K_N)$$

We know that the effect of an increase in the other region's capital stock must be to turn the terms of trade against manufactures and thus reduce profits; so $g_2 < 0$. The effect of an increase in the domestic capital stock is, however, ambiguous, since there are two effects: a worsening of the terms of trade and a reduction in unit input requirements. I will assume that the first effect outweighs the second: $g_1 < 0$. In other words, external economies are relatively weak. It is apparent that this is a conservative assumption which weakens the forces for uneven development. Nonetheless, divergence will still occur.

We have now set out a complete dynamic model in which the evolution of the two regions' industrial sectors can be followed from any initial position. The next step is to trace out and interpret the path of the world economy over time.

2. Dynamics of Uneven Development

The basic process which drives this model is extremely simple. As long as both countries produce agricultural goods, wage rates will be equalized by

trade; while because of the external economies in manufacturing production, whichever country has the larger capital stock will have a higher profit rate and will therefore grow faster. The result is an ever-increasing divergence between the regions, which ends only when a boundary of some kind has been reached. The outcome can differ slightly, depending on what sort of boundary limits the process.

Figure 1 illustrates the essential point, which is that no "interior" equilibrium--where both regions produce both manufactured and agricultural goods--can be stable. (A formal proof is given in the appendix). The lines $\rho_N = 0$, $\rho_S = 0$ indicate combinations of K_N and K_S for which profits in North and South respectively are zero. Given the assumptions in Section 1, these lines are downward-sloping. Also drawn in is a schedule along which the relative price of manufactures is constant, the dotted line TT. As we move northwest along TT, the profit rate must rise in North and fall in South, because of the external economies in manufacturing. As a result, the line $\rho_N = 0$ is less steep.

If we now recall that each region's capital stock will grow if profits are positive, shrink if they are negative, it is apparent that the behavior of the system near the interior equilibrium must be as indicated by the arrows. There is a knife-edge path leading to the equilibrium; but if either region starts with even a slightly larger stock of capital, there will be an ever-increasing divergence in that direction.

The divergence will continue until a boundary is reached. In this model boundaries are defined by the impossibility of having a negative capital stock, and by the fact that when a region's stock of capital reaches K_{max}, profits drop to zero and growth ceases. Figure 2 illustrates the boundaries and

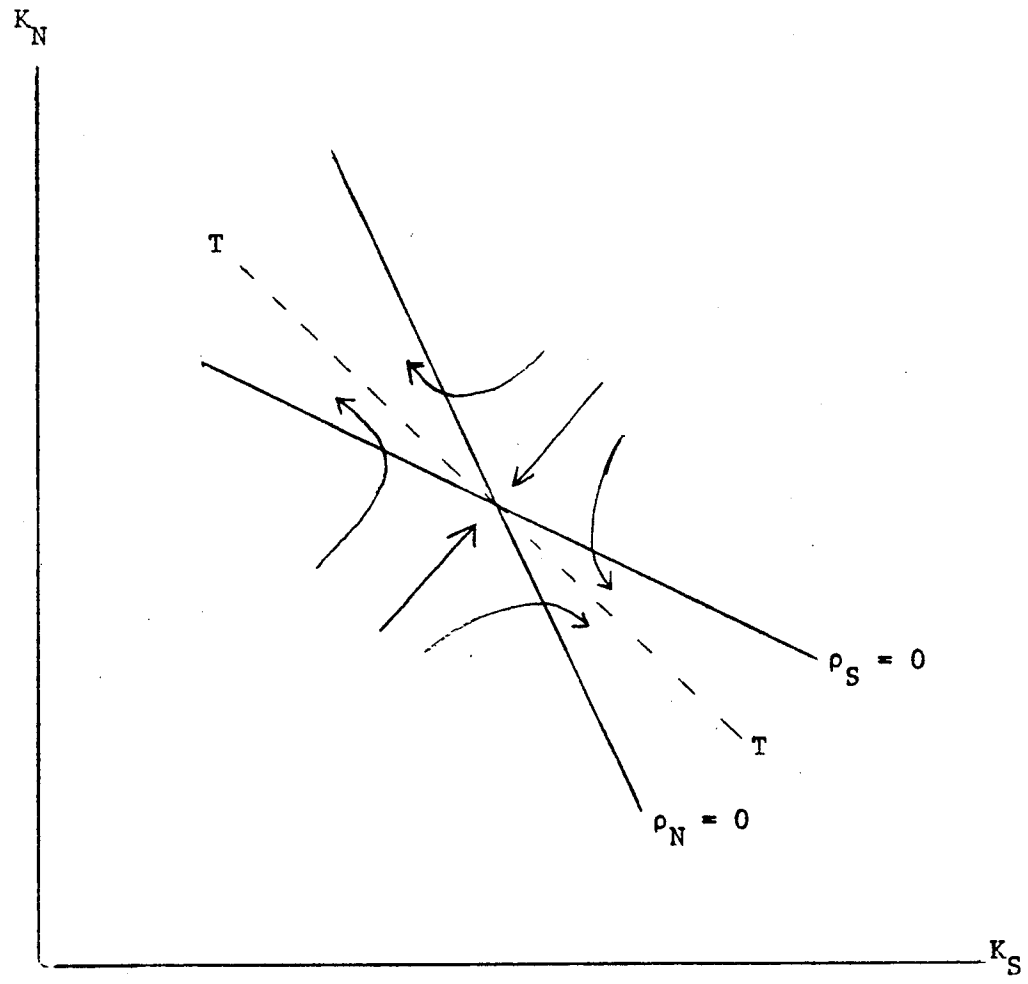

Figure 1

the interesting possible outcomes.[3/] One possibility is indicated by E_N^1, E_S^1. In each of these equilibria, the "underdeveloped" region has specialized completely in agriculture, while the "developed" region contains both agricultural and industrial sectors. At E_N^2 or E_S^2, by contrast, both regions specialize, the developed in manufactures and the underdeveloped in agriculture. Finally, at E_N^3 or E_S^3 the boundary is given by the exhaustion of investment opportunities in the developed region. The capital stock in the developed region is K_{max}, which implies that the region specializes in manufactured goods; meanwhile the underdeveloped region develops some manufacturing capacity, but continues to produce and export agricultural products.

Although these three cases differ slightly, they all involve a long run equilibrium in which the world has become differentiated into industrial and non-industrial (or at least less-industrial) regions. It would run against the spirit of the doctrine of uneven development, however, to conduct the analysis solely in terms of long-run solutions. Instead we should consider the whole dynamic story. Figure 3 illustrates how uneven development occurs, for the case in which both regions end by specializing. We start from an initial position such as A or B, in which one region has slightly more capital. There then follows a period in which both regions grow, but the already more developed region grows faster. As manufacturing capital grows, the relative price of industrial goods falls, until eventually a point is reached when the lagging region's industry cannot compete and begins to shrink. Once this starts, there is no check, because costs rise as the scale of the industry falls; and the lagging region's manufacturing sector disappears.

This is of course precisely what is supposed to have happened to the Indian textile industry in the eighteenth century. In effect the lagging region's

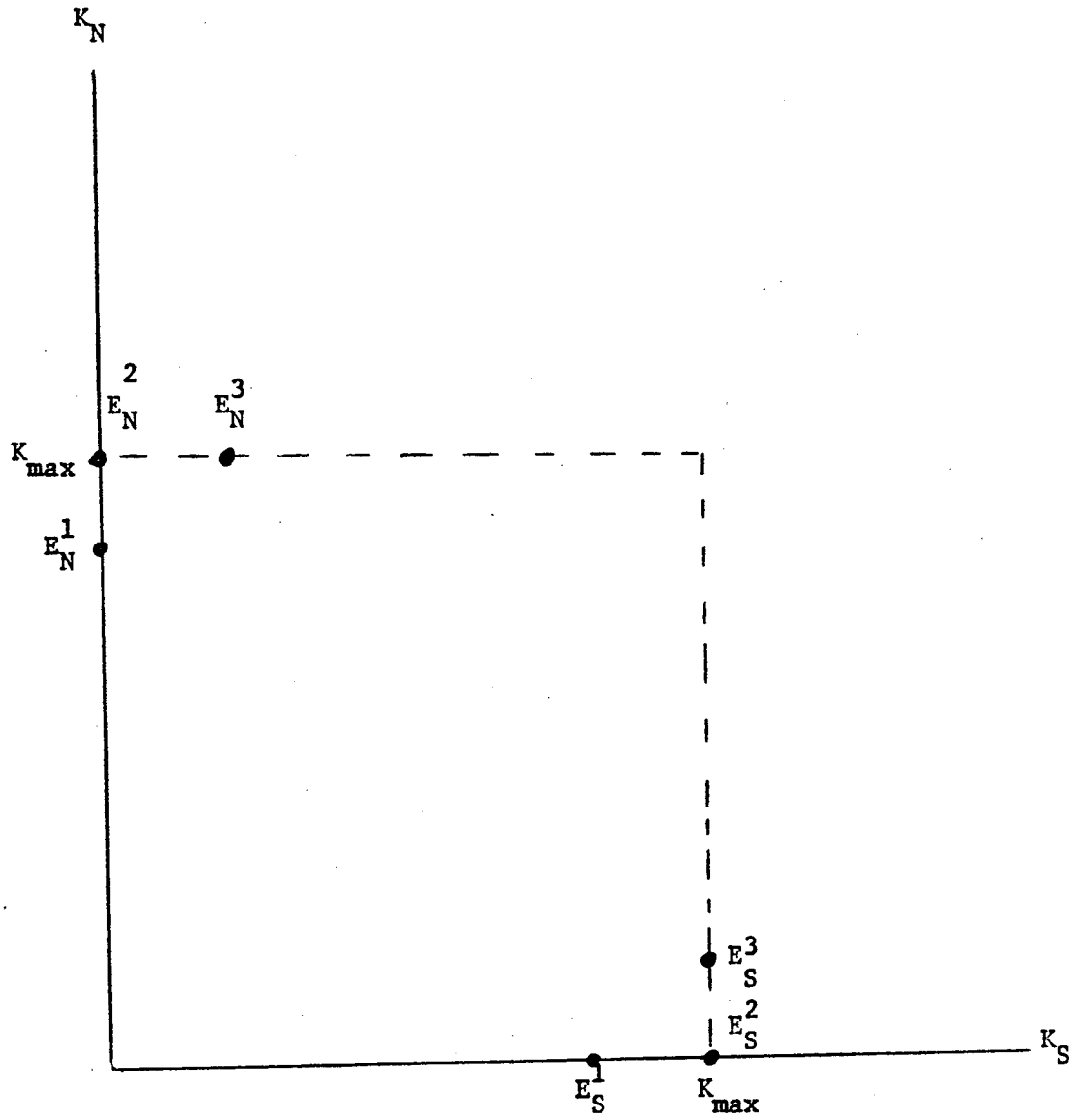

Figure 2

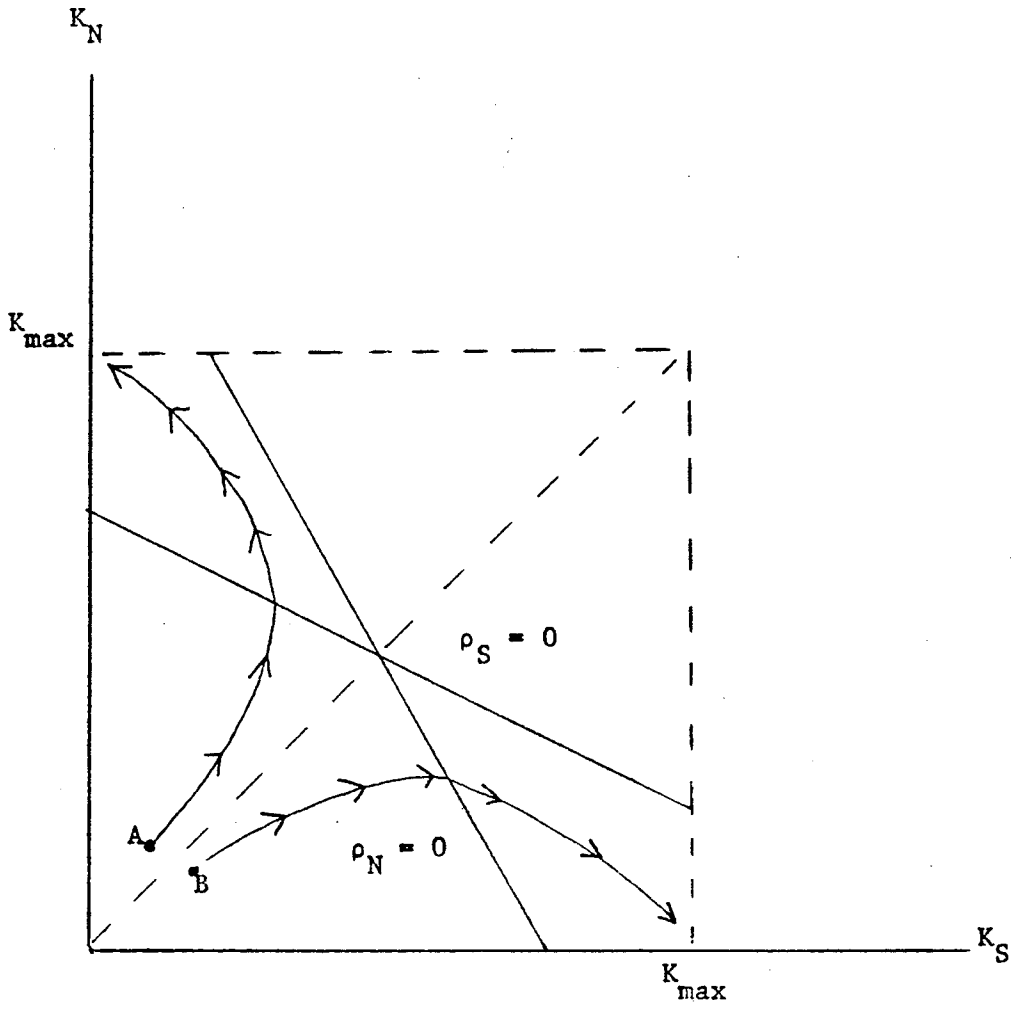

Figure 3

nascent industrial sector is destroyed by manufactured exports from the leading region, which is, according to Baran, what "extinguished the igniting spark without which there could be no industrial expansion in the new underdeveloped countries."[4/]

There are a number of interesting aspects of this story. Although the character of the long-run equilibrium is determined by tastes and technology, which region takes on which role depends on initial positions, i.e., on "primitive accumulation." Whether one prefers to explain the greater initial accumulation of capital in one region by the slave trade or the Protestant ethic, this is a model in which small beginnings can have large consequences. Another interesting aspect is the role played by trade. The divergence of capital stocks depends on the proposition that, as long as both countries are non-specialized, trade in goods leads to equalization of wage rates, i.e., of a factor price. There is thus a surprising affinity between the marxist theory of uneven development and the Heckscher-Ohlin-Samuelson model of trade.

3. International Investment

So far we have assumed that industrial growth must come from capital accumulation out of domestically earned profits. In this final section I will open up the model to allow international investment. The easiest way to do this is by making the extreme assumption that capital moves instantly so as to equalize profit rates in the two regions.

Again, we will be interested in the dynamic behavior of the world economy. In particular, we want to know if a Leninist view of the process can be justified. Lenin saw the evolution of the capitalist system as a two-stage process: "Under the old type of capitalism, when free competition prevailed, the export of goods was the most typical feature. Under modern capitalism, when monopolies prevail, the export of capital has become the typical feature."[5/] In this model, it turns out that Lenin's "stages" can occur, though this is only a possible outcome.

The working of the model under the assumption of perfect capital mobility is quite straightforward, and rests on one basic principle: that it is not possible for both regions to be unspecialized. For if both regions are unspecialized, their wage rates will be equalized by trade in agricultural products. The profit rate will then be higher in whichever region has the larger stock of capital, and capital will flow to that region. In particular, if the world capital stock is less than K_{max}, neither region can specialize in manufactures, and the initial position will necessarily be a point on one of the axes of our diagram.

What happens next depends on the particular characteristics of technology and demand, which determine how far industrialization goes. If the long-run equilibrium looks like E_N^1, E_S^1 in Figure 1, a declining relative price of manufactured goods will drive profits to zero and halt capital accumulation even before the leading region is completely industrialized. Another possibility, corresponding to E_N^2, E_S^2, is that accumulation continues until the developed region is completely industrialized, but that by that time P_M has fallen too far to allow profitable investment in the underdeveloped region.

Finally, if the long-run equilibrium is one in which both regions become at least partially industrialized, we have the Leninist case illustrated in Figure 4. There are two stages of capital accumulation. In the first stage, from A to B, the rate of profit is sustained and growth able to contine through increasing exports of manufactures to the underdeveloped region. When K_N reaches K_{max}, this process cannot continue. The reserve army of labor in North's agricultural sector is exhausted;[6/] the wage rate rises, and the profit rate falls sufficiently to induce capital to flow to the other retion. This inaugurates a second stage of accumulation--"imperialism, the highest stage of capitalism"--which depends on capital export from North to South, and is shown as the movement from B to C.

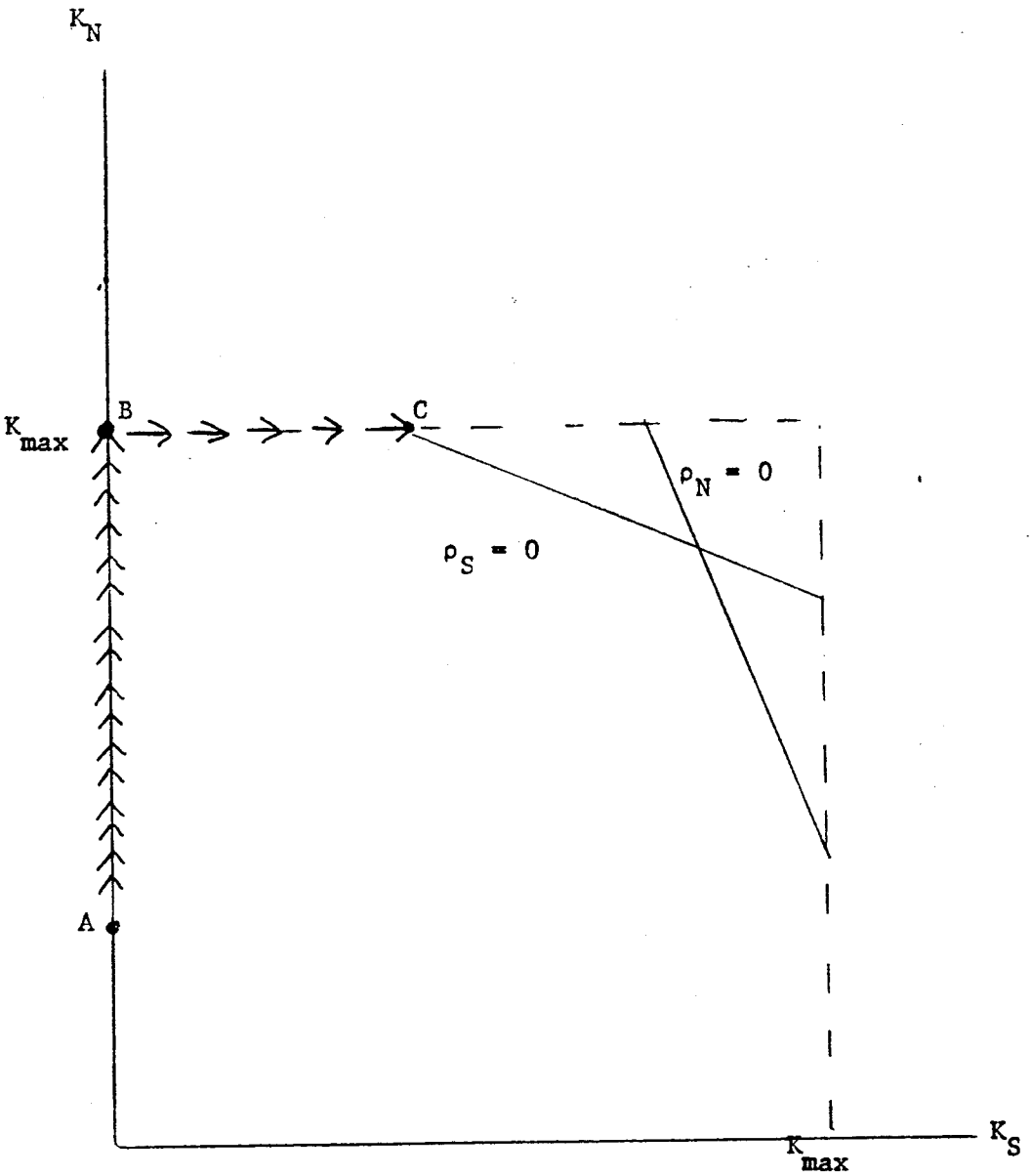

Figure 4

In addition to this shift in the mechanism of growth, the move from the first to the second stage of accumulation in this Leninist variant of the model also brings about an important change in the world distribution of income. There are three relevant groups: workers in North, workers in South, and capitalists. As long as we are in the first stage of accumulation, where the industrial region is not yet fully industrialized, the availability of labor from North's agricultural sector keeps wages equal in the two regions. In the "imperialist" stage, however, it is now profits which are equalized, by capital flows. Since industry is more efficient in the industrial region, Northern wages are now higher than Southern: the Northern workforce becomes a "labor aristocracy." This might mean that in addition to exporting capital, the industrial region might, in the second stage of growth, begin importing labor--a point also noted both by Hobson and by Lenin.

4. A Three-Region World

This final section considers an important extension of the analysis, to a world of three regions. Adding a region allows us to consider the possibility that the trend of international inequality may at some times be ambiguous, with a middle-income region growing faster than either high or low income regions.

Let us suppose, then, that there are three regions: Center, Semi-periphery, and Periphery, with capital stocks K_C, K_S, K_P. These regions will, like the two regions of Section 1, have identical tastes and technology. There will be assumed to be perfect mobility of capital between the regions. Finally, we will assume that Center has an initially larger stock of capital.

The dynamics of the three-region world economy are illustrated in

Figure 5. As before, there is a maximum stock of capital which can usefully be accumulated in any one region, thus defining the boundaries of a cube with a side of K_{max}. At the same time, only one region can be unspecialized at any given time; for if two regions were unspecialized, they would have equal wage rates and capital would flow to the region with the larger capital stock. Thus capital will initially accumulate in only one region, as shown by the movement from A to B. If it is still profitable, industrialization will then spread to one of the other regions, as shown by the move from B to C.

This second stage of capital accumulation is interesting in several ways. For one thing, which poor region becomes industrialized at this stage is arbitrary, and can be determined by historical accident or by small differences in the conditions of production between the two backward regions. Another interesting point is the direction of international capital movements, which go from the high-income region to the middle-income region, not to the poorest areas. Finally, notice that during this stage of world growth there simultaneously is a narrowing of the differential between the middle-income and the high-income regions, and a widening of the differential between the middle-income and low-income regions.

It would clearly be possible, by refining the assumptions of this model, to give it a much more realisitic feel. What is remarkable, though, is how much of what has been said about uneven development can be illustrated by an extremely simple model. This suggests that it may be fruitful, and useful to both sides, to apply the tools of orthodox economics to some of the ideals of the economic system's radical critics.

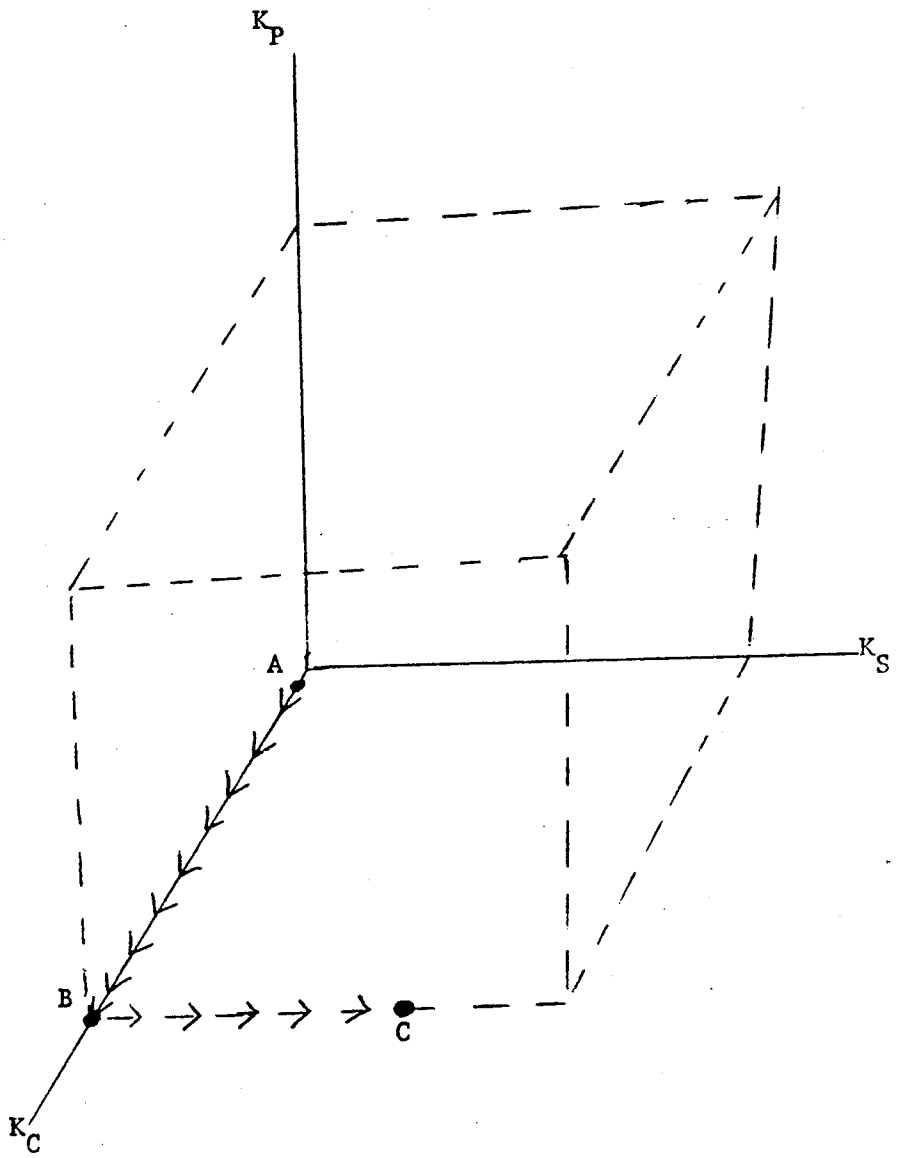

Figure 5

FOOTNOTES

1. The fixed-coefficient assumption is made for analytical simplicity, not because it plays any central role. There is nothing in this paper fundamentally opposed to capital-labor substitution, or to the theory of marginal productivity.
2. There is a fairly extensive literature on static trade models with external economies. For a discussion and bibliography, see Chacholiades (1978).
3. There are also some other possibilities. First, there may be several interior equilibria, all of them unstable. There can also be stable equilibria with $K_N = K_S = 0$ and with $K_N = K_S = K_{max}$.
4. The quotation is from Baran, cited by Sutcliffe (1972).
5. Lenin (1939), chapter 4.
6. Actually, this does not quite accord with Lenin, who argued that industrial countries still had a backward agricultural sector. Naturally the stylized model of this paper cannot do justice either to the richness or to the internal contradictions of Lenin's work.

REFERENCES

Baran, P. (1957): The Political Economy of Growth, New York, Monthly Review Press.

Chacholiades, M. (1978): International Trade Theory and Policy, McGraw-Hill, New York.

Frank, A.G. (1967): Capitalism and Underdevelopment in Latin America, Monthly Review Press, New York.

Lenin, V.I. (1939): Imperialism, the Highest Stage of Capitalism, International Publishers.

Lewis, A.W. (1977): The Evolution of the International Economic Order.

Myrdal, G. (1957): Economic Theory and Under-developed Regions, Duckworth, London.

Sutcliffe, B. (1972): Imperialism and Industrialization in the Third World," in B. Sutcliffe and R. Owen, eds., Studies in the Theory of Imperialism, London, Longman.

Wallerstein, I. (1974): The Modern World-System, Academic Press, New York.

Appendix: Instability of interior equilibria

In Section 2 of the paper it was stated that no "internal" equilibrium, i.e., one with both countries unspecialized, could be stable. This appendix provides a formal demonstration.

Begin by combining (6) with (7); then we have

$$\dot{K}_N/K_N = \rho(K_N, P_M) \tag{A1}$$

$$\dot{K}_S/K_S = \rho(K_S, P_M)$$

from which it is immediately apparent that at any equilibrium where $\dot{K}_N = \dot{K}_S = 0$ we must have $K_N = K_S = K^*$. Next consider (4), which we can write in the shorthand form

$$P_M = \pi(K_N, K_S) \tag{A2}$$

with $\pi_1, \pi_2 < 0$. As noted in the text, if $K_N = K_S$, $\pi_1 = \pi_2 = \pi^1$.

Now solve for $\dot{K}_N$, $\dot{K}_S$ and linearize around K^*:

$$\begin{bmatrix} \dot{K}_N \\ \dot{K}_S \end{bmatrix} = K^* \begin{bmatrix} \rho_1 + \pi^1\rho_2 & \pi^1\rho_2 \\ \pi^1\rho_2 & \rho_1 + \pi^1\rho_2 \end{bmatrix} \begin{bmatrix} K_N - K^* \\ K_S - K^* \end{bmatrix} \tag{A3}$$

An equilibrium will be unstable if either the trace of the matrix in (A3) is positive or the determinant is negative. But if $\rho_1 + \pi^1\rho_2 > 0$, the trace is positive; while if $\rho_1 + \pi^1\rho_2 < 0$, the determinant is negative. Thus any interior equilibrium is unstable.