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RESOURCE DEPLETION AND TERMS OF TRADE COLLAPSE:  
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by

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RESOURCE DEPLETION AND TERMS OF TRADE COLLAPSE:

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ABSTRACT

This paper considers the response of a labour-abundant developing economy, initially heavily dependent on a single resource, to depletion of that resource or to permanent collapse in the terms of international trade against the resource sector. It is shown that agriculture will be the new long-run growth sector. But if the country borrows abroad in order to maintain living standards in the short-run and medium-run following the resource sector collapse, the economy might be forced to repudiate its international debts even if growth occurs in the longer-run.

## RESOURCE DEPLETION AND TERMS OF TRADE COLLAPSE:

### "THE ZAMBIAN DISEASE"

Desmond Norton\*

#### I. THE PROBLEM

Consider a labour-abundant developing economy producing two composite commodities, tradeables (T) and nontradeables (NT). Unless indicated to the contrary (as in Section V), it is assumed that all production and imports are for final demand: domestic primary factors are the only inputs to production in each sector. Within each composite category the price relatives of goods are assumed constant until further notice. Those in T are determined by given world levels and the structure of protection. Tradeables consist of a resource-based sub-sector such as mining (R) as well as agriculture and manufacturing (AM). We suppose that the economy is initially heavily dependent on a booming R sector, the entire output of which is exported, but that the relevant minerals approach depletion; in comparative statics analysis we consider the extreme case of actual depletion. That is the direction in which the key (copper) resource sector of the Zambian economy has been moving in recent years. We examine how the structure of the economy is likely to react to such depletion, the difficulties it is likely to face and some implications for policy. We also consider a phenomenon in many ways similar to resource depletion -- that in which there is a substantial permanent shift in the

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terms of international trade against a resource upon which the economy had earlier been heavily dependent: Zambia has also had to face the latter dilemma in recent decades.

The past fifteen years have seen a good deal of research into the structural problems which a booming resource sector can create. The London Economist (1977) seems to have been the first printed source to have termed these as aspects of "the Dutch Disease", in view of the structural difficulties of the Dutch economy following major natural gas discoveries off its shores. Given the experiences of Zambia in recent years, it seems appropriate to label the problems associated with depletion / price-collapse of a previously crucial natural resource as symptoms of "the Zambian Disease".

Much of the literature on the Dutch Disease employs neoclassical trade-theoretic methods, assuming factor price flexibility and ensuing full employment, as well as equilibrium in the balance of payments on current account. However, such assumptions seem inappropriate for a developing economy in the face of a key resource collapse. In that context we can throw the Dutch Disease models into reverse only to a limited extent. Perhaps that is why what we have called the Zambian Disease has attracted little attention in the professional journals; see, however, both Daniel and Evans (1986).

Unless indicated to the contrary, it is assumed throughout that each good is produced under (industry) constant returns to scale, with strictly diminishing, but positive, marginal products to each variable input. Assuming that each sector uses only two factors of production, the discussion in Section II concerns mainly the short-run, defined as a period in which each sector competes for a common pool of intersectorally mobile labour (which moves to equate wages between sectors), but is constrained by a fixed amount of a sector-specific fac-

tor. The specific factor is capital in the case of NT, ore-bearing deposits in the case of R and capital in the case of AM. Along the lines of Neary (1978), the medium-run is defined as a period of disequilibrium, during which the economy is adjusting from short-run to long-run equilibrium. Comparative statics consideration of the long-run, when both capital and labour are mobile between sectors, is deferred mainly to Section III. Until indicated to the contrary, it is assumed that all factors are immobile internationally. Section IV turns to an important topical question in longer-run dynamics. This involves consideration of longer-run resource-transfer effects of current account international payments deficits which a developing country is likely to incur following depletion of R or permanent adverse movement in its terms of trade. The key question which arises is: If a lower-bound constraint is imposed on national (as distinct from domestic) product, under what circumstances will the country be unable to meet its international obligations in regard to interest payments? If it cannot do so, we say that there is no feasible solution to the model. Finally, Section V briefly reviews the Zambian experience in recent decades.

It will be concluded that, in labour-abundant developing economies, agriculture (A) will tend to be the key growth sector in the long-run following resource depletion or permanent terms of trade collapse against the resource sector. Technical change is ignored. However, it will become apparent that if labour-augmenting technical change is introduced, and if the rate of such change is no lower in agriculture than in the other sectors, then A will remain the key long-run growth prospect following depletion of the resource or collapse in its price.

## II. THE SHORT-RUN

### II. 1. Short-Run Response to Resource Depletion

Given the allocation of capital between sectors, we start with the economy initially in short-run equilibrium during the boom era, prior to depletion of R, at point B on the production frontier PP' in Figure 1. It is assumed in Figure 1 (and in the subsequent Figure 2) that point B is also a position of long-run equilibrium, which implies that PP' is nested in, and tangent to, a long-run transformation locus (not drawn) at point B (see Mayer, 1974). For reasons to be indicated shortly, PP' has for the moment been drawn perfectly flat at low production levels of T. That would be the case if, after resource depletion, the reduction in potential T production (reflecting potential R production of zero) were the same at all levels of NT production. That would imply that  $MC_T = 0$  ( $MPL_{NT} = 0$ ) along PP' to the left of point Z (a case of pure labour surplus) and that at any level of NT production less than P, the slopes of the two transformation curves would be the same.

If factor prices were flexible, the economy after resource depletion would move to a point on the full-employment short-run locus PP'', the exact point depending on the pattern of demand. With a large share of NT output presumably being accounted for by services, it is empirically reasonable to assume that neither composite commodity is inferior: we therefore adopt assumptions of normality. Hence, due to the fall in aggregate demand, the price of NT must fall following resource depletion. Because slopes at B and C in Figure 1 are the same, and because NT is a normal good, the new equilibrium must be to the right of point C. For similar reasons, given increasing opportunity costs as we move down a transformation frontier, the new equilibrium cannot be beyond, or even very close to, point D. Thus the equilibrium

must be at some point strictly between C and D, at, say, E. Assuming that a situation like that depicted in Figure 1 applies, it follows from these observations that in the short-run, in consequence of resource depletion alone: (i)  $P_{NT}$  would fall relative to  $P_T$ ; (ii) NT production would fall; (iii) Although total T production would fall, it can be shown, directly from Figure 1, but more clearly using diagrams similar to Figures 3 and 4 below, that production of AM would increase.

Following the approach in the seminal paper on Dutch Disease phenomena by Snape (1977), it was in order to clarify thinking on bounds for the new short-run equilibrium that we assumed that  $PP''$  in Figure 1 was merely a horizontal displacement of  $PP'$ . The diagram implies that at any level of NT (other than at level P) the marginal cost of T is the same before and after resource depletion. However, with positive marginal products to the variable factor,  $PP'$  will not be zero-sloped to the left of point Z. Furthermore, in a neighbourhood of any given NT production level, a reduction in NT could initially divert labour into both R and AM, but after resource depletion the released labour can flow into AM only. Hence, at any NT production level, the marginal cost of T will increase after resource depletion, which means that the slope of  $PP''$  will be steeper than that of  $PP'$ . Thus we assume that the situation is as in Figure 2, which implies that marginal costs are always positive, and that at any level of NT production, the marginal cost of T is higher after resource depletion.

Figure 2 indicates that even in the assumed absence of goods inferiority, production of NT could increase after resource depletion, since now the absolute value of the slope of  $PP''$  at C exceeds that of  $PP'$  at B. Hence it is possible that production of NT will increase, consistent with the fall in  $P_{NT}$ . If production of NT is increased, that of T will be reduced all



the more so. Thus, assuming factor price flexibility, the short-run effect of resource depletion on production of NT is a priori indeterminate: while reduced income discourages demand for NT, its reduced price increases quantity demanded while its lower marginal cost encourages increased production of NT<sup>1</sup>. However, as will be shown in Figures 3 and 4 below, with diminishing marginal physical products to labour in each of the two composite sectors (or with diminishing marginal physical products to labour in one sector, and with a constant marginal product of labour in the other sector), production of AM must increase.

In summary, assuming factor price flexibility, the market's short-run response to depletion in the R sector will be: (i)  $P_{NT}$  will fall relative to  $P_T$ . (ii) Production of T will fall. (iii) The effect on NT is a priori indeterminate: NT production could increase, decrease or stay as it was. Only if the reduction in  $P_{NT}$  is sufficiently small (and if the new  $MC_{NT}$  is sufficiently low) would production of NT increase. (iv) Production of AM will increase.

Suppose that the transformation curves are as in Figure 2, and consider the short-run impact of resource depletion on factor returns. The main reason why we are interested in this question is because, if the short-run return on capital rises in one sector relative to the others, then the former sector will tend to expand in the medium-run (and will therefore have expanded in the new long-run equilibrium) until returns on capital are again equated

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<sup>1</sup> The general equilibrium effects of resource depletion or terms of trade collapse can be decomposed into resource movement (supply side) effects and spending effects (Corden and Neary, 1982). In the present case, it is probable that production of NT will fall because: (a) the spending effect on NT depends on the marginal propensity to consume NT, which will be large since "in mineral-exporting LDCs where increased government spending on construction and public services is likely to be the main channel for use of mineral rents, the marginal propensity will be high." (Daniels, 1986, p. 4). (b) The resource movement effect on NT depends on the relative use in each sector of the mobile factor, labour. If (because of the predominance of a very labour-intensive subsector A in AM) NT is capital-intensive relative to AM, then this effect will be small.

across sectors. With tradeables as the numeraire in terms of which prices are expressed, we continue to assume flexible prices, so that factor returns adjust to clear markets. The direction of response in the other endogenous variables after the fall in  $P_{NT}$  is determined by the change in the value marginal product of labour in NT,  $V_{NT}$ . The operation of the factor market in the case in which the decline in  $P_{NT}$  induces an increase in NT production is depicted in Figure 3.

The locus of the value marginal product of labour in tradeables,  $V_T$  in Figure 3, is the horizontal sum of  $V_R$  and  $V_{AM}$ .  $V_{NT}$  is measured in terms of tradeables. We start with full employment at point B with returns to labour being equated across markets. Employment in NT, T, R and AM can be read directly from points B, B' and B". After resource depletion, the locus  $V_R$  is no longer relevant, so  $V_T$  goes to  $V_{AM} = V_{T'}$ . If  $P_{NT}$  did not change, the new equilibrium would be at point F. However, we have seen that resource depletion induces reduction in  $P_{NT}$ ; hence the  $V_{NT}$  locus shifts downwards by a constant proportionate amount to, say,  $V_{NT'}$ . The new equilibrium is therefore at point G in the diagram. Because of positive marginal products, and because employment in the AM and NT sectors have both increased, the output of those two sectors increases.

In regard to the short-run response of factor returns, by assumption there is no longer a specific factor in the resource sector, which no longer exists, and all labour previously there has moved to the NT and AM sectors. In the NT sector, because production becomes more labour-intensive, the return on capital has increased in terms of NT; however, it could have increased or decreased in terms of AM, due to AM's higher relative price. In the AM sector, because production there is also more labour-intensive, the return on capital has increased

in terms of AM, and, given the improved internal terms of trade of that sector, in terms of NT also. Figure 3 also indicates that in terms of AM, the wage rate common to all sectors falls. Furthermore, the same diagram shows that since the output of NT increases, the wage rate in terms of NT falls. The real wage, therefore, unambiguously falls. Thus, if (as in Figure 3) the output of NT expands in short-run response to resource depletion, and assuming wage flexibility: (i) The real return on capital in NT could increase or decrease. (ii) The return on capital in the AM sector unambiguously increases. (iii) Real wages unambiguously fall.

The case in which production of NT is reduced in response to the fall in  $P_{NT}$  is illustrated in similar fashion in Figure 4. In this case we start at point B, but  $P_{NT}$  falls by more than in Figure 3.  $R$  goes to zero as before. For labour market clearance,  $V_{NT}$  and  $V_{AM}$  must now intersect to the southeast of point B. This occurs at a point like G in Figure 4. In the NT sector, because production becomes more capital-intensive, the return on capital in terms of NT falls, and, due to AM's higher relative price, it falls in terms of AM also. In the AM sector, because production there becomes more labour-intensive, the return on capital has increased in terms of AM, and, given the improved internal terms of trade of that sector, it has increased in terms of NT also. However, in contrast to the case examined in the immediately preceding paragraph, the effect on the real wage is ambiguous: in terms of NT it increases while it falls in terms of AM. Thus, depending on a worker's consumption pattern, his real wages may rise or fall. In summary: (i) The real return on capital in NT falls. (ii) The return on capital in AM unambiguously increases. (iii) Real wages could rise or fall.

Suppose that we start at point B in Figures 2 and 3 or 4 before resource depletion, but that real wages, in terms of, say, food, are completely rigid in a downward direction; thus real wages in terms of tradeables cannot fall. In the context of a developing economy, that might be because real wages are at some (possibly conventional) subsistence level to begin with, and because nobody is willing or able to work at a wage below that subsistence level. After resource depletion, employment in the AM sector stays unchanged at B" in Figures 3 and 4. If  $P_{NT}$  stayed unchanged, unemployment would go to BB". But  $P_{NT}$  would in fact tend to fall, the reduction in  $P_{NT}$  being accentuated by the spending effect of unemployment. The net effect on unemployment would then depend on the extent of the price fall -- on the extent to which  $V_{NT}$  shifted downwards in the two diagrams. All we can say is that unemployment will rise to a level greater than BB" in the two diagrams.

An extreme case of real wage rigidity has just been considered. It is more likely that wages will be rigid at levels in excess of the post-resource-depletion full employment level, but generally below the initial pre-depletion level. Then, in the medium-run, and under the experience of unemployment, the ratchet effect of what was initially a relatively high real wage is likely to wear off, and the level at which real wages are rigid, as well as the unemployment level, will tend to decrease gradually over time. But if, as in some developing countries, there is an absolute floor to the real wage, and if that floor (eg. due to subsistence requirements) is higher than the new market-clearing level, then some unemployment will be sustained over time. (Note that this does not imply that there was necessarily unemployment before the resource-based sector came on stream. Decades of increased income due to the resource sector boom are likely to have induced population growth.) In the absence of famine among a given population, the labour force must continue to consume at or above a subsis-

tence level. Given factor endowments and the structure of output, it may continue to do so over a medium-run of several years if the economy runs deficits in the balance of payments on current account. Malthusian checks and emigration may also come into play over a lengthy (medium-run) disequilibrium period, causing the economy's labour endowment to shrink. Current account deficits combined with population decay, as well as readjustment of capital between the AM and NT sectors, may operate together for some decades. For long-run development, the economy will have to restructure, so that AM production is further increased.

## II. 2. Short-Run Response to Terms of Trade Collapse

Placing the question of resource depletion for the moment aside, consider now the effects of a permanent adverse movement in the terms of international trade against the key resource-based activity -- as already stated, Zambia has also had to grapple with this problem in its copper-producing sector. Following the general approach up to now, we first examine the effects over a time period in which the specific-factor endowments of each sector stay fixed. Because relative prices within tradeable goods have changed, it is no longer convenient to take composite tradeables as the numeraire. We therefore take only the AM subset of such goods as the units in terms of which prices are measured.

Assume, because of a permanent collapse in world demand (due, for example, to development of substitutes) that the price of the key resource-based good falls by  $x$  percent. Consequences can be read from Figure 5. The initial equilibrium is at point B in the diagram, from which employment in tradeables and nontradeables, and in the AM and R subsectors, can be read directly from points B, B" and B'. After the collapse in  $P_R$ ,  $V_R$  (measured in terms of AM) falls by  $x$  percent to  $V_{R'}$ . The value marginal product of labour in tradeables is now given

by  $V_{AM}$  for relatively low  $L_T$ , but goes to the dashed locus  $V_T'$  for higher  $L_T$ . If  $P_{NT}$  did not change, the new full employment equilibrium (in the case of factor price flexibility) would be at point C in the diagram. Output of both AM and NT would then increase, while that of R would contract. Although the relative price of R has now fallen, there can be no domestic substitution effect in favour of that commodity because, by assumption, all of its output is exported. There will, however, be an income effect operating against NT. Given that the transformation frontier is unchanged, and on the plausible assumption of non-inferiority, the demand for and price of nontradeables will fall. Therefore the new equilibrium must be one at which production of and hence employment in nontradeables will have contracted. Thus  $V_{NT}$  will shift downwards sufficiently far -- to, say,  $V_{NT}'$  -- so as to cause the intersection of  $V_{NT}'$  and  $V_T'$  to be located to the south-east of point B, at, say, point D in the diagram. Comparing the initial equilibrium at B with the new short-run equilibrium at D, we see (assuming factor price flexibility) that following the adverse terms of trade movement (a) the output of tradeables expands while nontradeables contract and (b) the output of AM expands while the R sector contracts.

Short-run distributional effects of the adverse terms of trade movement are very similar to those applying in the case of resource depletion inducing contraction of output in the NT sector. In regard to factor returns in terms of AM (the key determinant of living standards in a developing country), and still referring to Figure 5: (i) The return to labour falls (in all sectors) from that represented by point B to that represented by point D<sup>2</sup>. (ii) With a lower employment level in R, that sector's specific-factor intensity increases. For this reason, and

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<sup>2</sup> However, inspection of Figure 5 indicates that wages rise in terms of NT. Because it is likely that this will be of relatively small importance in determining workers' living standards, it is ignored in what follows.

also because the price of R has fallen, the specific factor rental in terms of AM falls in R. (iii) Because production in NT becomes more capital-intensive, that sector's return on capital, in terms of NT, also falls, and the decline in  $P_{NT}$  reduces the return on capital in terms of AM in the NT sector all the more so. (iv) The only class which gains in the short-run is capitalists in the AM sector, who get the same prices as earlier for their outputs, but who now hire labour more cheaply.

It is easy to see from Figure 5 that if wages are rigid at any level above that at point D, then unemployment will prevail. Such unemployment would be higher than that suggested by the  $V_{NT}$  locus, for with workers then idle, spending on nontradeables would fall by more than that implicit in the diagram, causing  $V_{NT}$  to shift further to the right than depicted. Note that (further complications aside) capitalists in AM would still gain if wages were rigid at levels strictly between those implied by points B and D.

If wages are rigid downwards at levels higher than the new market-clearing level, the economy is likely to react to an adverse movement in the terms of trade against the resource sector in a manner similar to its response to resource depletion with wage rigidity. (But note that it is likely that there would be a problem of recognition in the terms of trade case, which might not occur in the event of depletion.) Thus Malthusian-type population checks (perhaps supported by government programmes), current account deficits in the balance of international payments, as well as intersectoral capital stock adjustment, may operate together in the medium-run for some decades. And, as in the case of resource depletion, for long-run development the economy will have to restructure, so that AM production is further expanded.

### III. LONG-RUN COMPARATIVE STATICS, AND SOME POLICY IMPLICATIONS<sup>3</sup>

#### III. 1. General Issues

A common error incurred by policymakers with regard to the problem of the "Zambian Disease" (or the Dutch Disease) is in estimating its duration. The disease and its effects are often assumed to be transitory (Daniel, 1986, pp. 1, 7), and various attempts are made to ease the symptoms rather than to cure the illness directly. The situation is then compounded as the side-effects of the prescribed cure become problems in themselves.

If the economy is approaching total depletion of a resource, then recognition of the problem as one of a permanent nature is likely to be fairly fast. If, however, the problem is caused by a lasting movement in the terms of trade against the R sector, recognition and consequent adaptation may be slow. Deterioration in the terms of trade has often been thought to be a temporary phenomenon and so policymakers' "cures" may also be temporary. Typically, large deficits will be run on the balance of payments on current account, and the currency will be maintained at an overvalued rate in the hopes of avoiding the inflationary effects of a devaluation.

#### III. 2. Resource Depletion: Long-Run Comparative Statics

Still ignoring long-run resource-transfer effects of the initial current account international payments deficits incurred in response to the loss of R, and for the moment taking population as given for purposes of exposition, consider now some general features of the

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<sup>3</sup> Much of the reasoning in this section can be verified utilising the distinction between resource movement effects and spending effects of decay in R: See Corden and Neary (1982), especially pp. 832-5.



medium-run and long-run restructuring of the capital stock between sectors following depletion of R and subsequent to the reallocation of labour in the short-run. In the long run there will generally be some restructuring of the capital stock between the NT and the AM sectors, and between the A and manufacturing (M) subsectors.

We have seen that in the short-run following resource depletion, the return on capital in the NT sector could increase or decrease in terms of either NT or AM, whereas in the AM sector it increases in terms of both AM and NT. How capitalists perceive the real relative changes in the return to capital in those two sectors could therefore depend on their consumption patterns and on the extent of the reduction in  $P_{NT}$ . Thus whether the return on capital in NT relative to AM definitely increases or decreases is indeterminate in the short-run. Therefore, in the absence of further assumptions, we cannot definitely determine the directions of change in the NT and composite AM sector outputs in the long-run.

In the context of adjustment in the medium-run toward long-run equilibrium, we make the plausible assumption that manufacturing is the highest, NT is intermediate, and A is lowest, in capital intensity. Because A is likely to be large relative to M in developing countries, it is also assumed that AM as a whole is labour-intensive relative to NT. According to Henry's input-output transactions table for Ireland in 1976 (Henry, 1980, Appendix 1), the direct requirements capital/labour ratio -- measured as capital per man-year in thousands of pounds -- was: agriculture, 4.1; trade margin and services, 11.0; economy-wide average, 10.7. Given the importance of agricultural output and employment in Ireland, these figures imply that industry was more capital-intensive than services (which accounted for the bulk of non-tradeables), and that it was certainly much more capital-intensive than agriculture. The rel-

ative capital intensity of agriculture in developing countries is presumably even lower. Hence the assumption (supported by the estimates for even the developed economy of Ireland just cited) that AM as a whole is more labour-intensive than NT in developing countries.

In the long-run after resource depletion, the economy can be viewed as one of the Heckscher-Ohlin type with two subsectors, NT being capital-intensive while AM is labour-intensive. With the aggregate capital stock given but mobile between these two subsectors, the release of labour from R (at given output prices) will cause the labour-intensive sector, AM, to expand absolutely, while NT will contract in absolute terms (Rybczynski, 1955). Given the plausible assumption of normality, the contraction of NT will in fact be accentuated by the fall in demand for that good. We can therefore safely take it that the AM sector will expand absolutely in the long run after the R sector has released its labour to the rest of economy, and after capital stock reallocation between NT and AM. In what follows, we take the long-run reallocation of capital between NT and AM as given, and focus on adjustments of the non-NT capital stock within AM alone.

An increase in the AM sector's endowment of labour is an effect of depletion of R in both the short-run and long-run. Given AM's long-run equilibrium capital stock, the market response to that increased labour endowment will induce the labour-intensive subsector -- agriculture -- to expand absolutely, while the capital-intensive subsector -- manufacturing -- will contract. This is because the economy has shifted from a position of comparative advantage in the production of R, to one of comparative advantage in the production of A. We are assuming that following depletion, the country is relatively well endowed with labour and relatively poorly endowed with capital. (This is in fact a characteristic feature of most

developing countries.) It follows that after resource depletion, agriculture must be the principal long-run growth sector, and that policies which impede agriculture during the resource boom and in the medium-run following resource depletion will impede long-run growth.

The economy must rely on the AM sector for further growth and foreign earnings since it is the only remaining export sector following depletion in R. As such, it warrants further examination. Following resource depletion, the wage rate (in terms of tradables) falls in the short-run. The AM sector reacts to this by increasing its labour intensity. In the medium-run, the A component expands relative to M since resource depletion has removed the country's comparative advantage in the production of R, whereas increased labour supply to the rest of the economy, coupled with the relative scarcity of capital, has shifted comparative advantage toward the labour-intensive commodity, A.

Interference by the policymaker becomes necessary when growth in A is impeded. There are two principal reasons why growth in A might be retarded. Firstly, the AM sector in general, and A in particular, may have missed out on some sort of "learning by doing" while the boom prevailed in R. We assume that such learning by doing is external to the firm, and, in the spirit of the Neary-van Wijnbergen (1985) model, the question which arises is whether or not an existing subsidy to the AM sector (introduced to correct the existing market failure) should be increased during the boom. Secondly, the wage rate after the boom is over may be rigid at too high a level, thereby preventing A from acquiring the additional labour necessary for expansion. This will occur especially where wage indexation or long-term wage contracts are common.

The policymaker faced with a boom which is expected to be temporary can interfere with market forces by either allowing the boom to operate freely and by taxing resource-based profits which can then be distributed to AM, or he can pursue a policy of wage restraint which would enable AM to hire enough labour to continue production. In pursuing the former option and further subsidising AM, support would be given not only to A but to M also. The policymaker would have to ensure that subsidies were biased toward A, since comparative advantage after the boom lies with this sub-sector. However, care should be taken not to oversubsidise the sector in the same way that infant industries are sometimes oversubsidised. Correctly administered, this policy would minimise loss of learning by doing, but in the aftermath of the boom there could still be a problem of wage rigidity, so that continued subsidisation of AM might be necessary to allow for growth in A.

Alternatively, policy could opt for wage restraint. There would then be reduced incentive for labour to move from AM (or NT) to R during the boom, so that AM could continue to operate (and therefore would not miss out on learning by doing), but on a smaller scale than before. An advantage of wage restraint is that it sets living standards during the boom at levels from which downward flexibility might be easier. During the boom period, living standards, in the presence of a free labour market, might have increased substantially. In consequence, workers' expectations may cause wages to become rigid at high levels as their conception of subsistence is revised upwards. As Corden (1984, p. 359, note) suggests, "it might be argued that the true Dutch Disease in the Netherlands was not the adverse effects on manufacturing of real appreciation but rather the use of Booming Sector revenues for social service levels which are not sustainable, but which it has been politically difficult to reduce." Restraining the wage at a lower level could prevent this. The A component of AM



would be the principal beneficiary from this action, since it is labour-intensive. The benefits from a policy of wage restraint would, however, have to be measured against its negative effect on population growth.

It is important to note that A is identified as the future growth sector solely because it is labour-intensive, and because the economy is assumed to be relatively abundant in labour while capital is relatively scarce. Following resource depletion, the availability of labour to the rest of the economy is increased as the R sector releases its labour supply. Because A is labour-intensive in production, it will expand relative to M.

For simplicity assuming full employment and (for the moment) fixed production coefficients, growth in A can be viewed in the following terms: Given the long-run equilibrium capital stock of AM, there are two constraints within the AM sector:

$$b_{La}X_a + b_{Lm}X_m = L$$

$$b_{Ka}X_a + b_{Km}X_m = K$$

where  $X_a$  and  $X_m$  represent agricultural and manufacturing production respectively, the  $b_{ij}$  represent the input requirements per unit of output, and  $K$  and  $L$  denote the labour supply and capital stock, respectively. These constraints are shown in Figure 6a, where the locus  $KK$  intersects  $LL$  from below, reflecting the fact that  $M$  is capital-intensive relative to  $A$ . As the  $R$  sector collapses (not shown in the diagram), an increase in the endowment of labour to  $AM$  is shown by an outward shift in  $LL$  in the diagram; production, which was initially at  $B$  is now at  $H$ . Thus there has been an absolute increase in production of  $A$  (which is labour-intensive) and an absolute fall in production of  $M$  (which is capital-intensive).

Figure 6b shows the same results in Edgeworth Box form, where B' and H' correspond to B and H in Figure 6a. The horizontal dimensions of the box increase as labour is freed from sector R and the endowment of labour in AM increases. The above analysis assumed fixed coefficients of production, for simplicity. However, even allowing for substitutability of factors, the Rybczynski (1955) result still holds: as the labour endowment of AM increases, capital intensities in A and M do not change, so we still get the same box diagram result.

This Rybczynski result, which (given the long-run equilibrium level of K in AM) predicts that the increased labour supply available to AM will induce an absolute increase in production of the labour-intensive good (A) and an absolute fall in production of the capital-intensive good (M), coupled with the assumption that the economy is relatively abundant in labour and relatively scarce in capital, will ensure expansion in A ceteris paribus. It is the role of policy to encourage this expansion and to correct market failures which impede its occurrence.

### III. 3. Terms of Trade Collapse: Long-Run Comparative Statics

Having considered long-run effects of resource depletion, we again return to effects of a permanent adverse movement in the terms of international trade against the resource sector. This time the focus is on the long-run. It is possible, of course, that the terms of trade will have moved so much against the resource sector as to make production in R prohibitive. In that event the long-run analysis would be virtually identical to that of resource depletion. In what follows in this subsection it is therefore assumed that the terms of trade movement does not cause R sector output to go to zero in the long run. We again take AM as the numeraire in terms of which prices are measured.

that in the long-run, in consequence of permanent terms of trade deterioration against R, NTM would contract, and A would expand, in absolute terms. Hence, because it is labour intensive, A would be a key growth sector in the long run, even if the labour force were constant. Policies unfavourable to A in response to the terms of trade deterioration are therefore likely to suppress long-run growth. Wage rigidities, which impede the mechanisms just outlined, operate to the same effect.

#### IV. LONG-RUN DYNAMICS: DOES A FEASIBLE SOLUTION EXIST?

It has been noted, in the face of resource-sector depletion and/or in response to permanent adverse movement in the terms of trade, that the authorities might deliberately operate current account balance of payments deficits -- ie. borrow abroad -- in order to maintain living standards at or above some floor level. This might reflect sustained errors in recognition of the underlying problem, or, if its permanence is promptly recognised, the intent might be to repay, after restructuring the economy, the debts thereby incurred. The question arises as to whether there would then be a feasible solution for the model: If a constraint floor is imposed on national (as distinct from domestic) product, what are the implications for borrowing behaviour, interest rates, longer-run growth and other variables, if the country is not ultimately to be forced into repudiating its debts, or if the lending countries do not write off their past loans?

In order to highlight some of the issues involved, consider a situation in which the population stays constant at its immediate pre-crisis level, and suppose that domestic product gradually decays following the beginning of the depletion and/or terms of trade crisis, at a

constant rate  $\gamma$ , over the period  $0 < t < \tau$ . It is assumed that the economy gradually and simultaneously is restructuring its output. Hence, over the (possibly lengthy) interval  $0 \leq t \leq \tau$ .

$$(1) \quad Y(t) = Y(0)e^{-\gamma t} \quad \gamma > 0,$$

where  $Y(0)$  is the immediate pre-crisis (end of boom era) level of domestic product, initially assumed to equal national product; thus it is assumed for simplicity that there are no net factor payments to/from abroad to begin with. Setting  $Y(0) = 1$ .

$$(2) \quad Y(t) = e^{-\gamma t} \quad 0 \leq t \leq \tau.$$

National product is

$$(3) \quad \tilde{Y}(t) = Y(t) - iD(t),$$

where the interest rate on debt,  $i$ , is positive (assumed constant) and  $D$  is external debt outstanding. It is assumed that in an attempt to maintain living standards, the country operates a current account international payments deficit equal to a constant proportion,  $\beta$ , of the difference between the pre-crisis level of national (and domestic) product and its current national product. Thus

$$(4) \quad D(t) = \int_0^t \beta(1 - \tilde{Y}(t))dt, \quad 0 < \beta < 1.$$

Hence, for  $0 \leq t \leq \tau$ ,



$$(5) \quad \tilde{Y}(t) = e^{-\gamma t} - 1\beta \int_0^t (1 - \tilde{Y}(t)) dt.$$

As shown in the appendix, manipulating (5), and setting  $\tilde{Y}(0) = Y(0) = 1$ , implies

$$(6) \quad \tilde{Y}(\tau) = 1 + \{\gamma/(\gamma + 1\beta)\}[e^{-\gamma\tau} - e^{1\beta\tau}].$$

It is assumed that following the decline and ultimate restructuring, domestic product reaches a low-level equilibrium at  $t = \tau$ , and that thereafter it either stays constant or grows at rate  $\alpha$ . Hence, for  $t \geq \tau$ ,

$$(7) \quad Y(t) = Y(\tau)e^{\alpha(t - \tau)}, \quad \alpha \geq 0.$$

So, observing equations (1) and (7), and letting the parameter  $A$  denote  $e^{-\gamma\tau}e^{-\alpha\tau}$ , for  $t > \tau$ :

$$(8) \quad Y(t) = Ae^{\alpha t}.$$

Hence

$$(9) \quad \tilde{Y}(t) = Ae^{\alpha t} - 1\beta \int_0^t (1 - \tilde{Y}(t)) dt,$$

where, from equation (3), the carry-forward interest burden of debt incurred before  $t = \tau$  is embodied in the  $\tilde{Y}$  term on the right hand side. Proceeding as with equation (5) above, it is shown in the appendix that, for  $t > \tau$ , (9) implies

$$(10) \quad \tilde{Y}(t) = \alpha A(e^{\alpha t} - e^{\alpha \tau} e^{-i\beta \tau} e^{i\beta t}) / (\alpha - i\beta) + 1 \\ + [\gamma / (\gamma + i\beta)] (e^{-\gamma \tau} - e^{i\beta \tau}) e^{i\beta (t - \tau)}$$

Clearly, if  $\alpha = 0$  (the case of no growth in domestic product from its low-level equilibrium at  $t = \tau$ ), equation (10), which, the reader is reminded, applies for  $t > \tau$ , indicates that

$$(11) \quad \tilde{Y}(t) = 1 + \text{Constant} [e^{-\gamma \tau} - e^{i\beta \tau}] e^{i\beta (t - \tau)}, \quad \text{Constant} > 0.$$

Because  $\gamma$ ,  $\tau$ ,  $i$  and  $\beta$  are all positive,  $-\gamma \tau < i\beta \tau$ , implying that [...] in (11) is negative. Thus  $\tilde{Y}(t)$  will more rapidly fall below any positive floor constraint level the higher the values of those four parameters, and will ultimately become negative. In this case the model has no feasible longer-run solution, meaning that lenders will have to write off the debt, or that the country will be forced to repudiate it, or that a continuously shrinking population due to Malthusian catastrophe and/or mass exodus, are the only alternatives.

It should also be clear, if the country does borrow abroad during the years of decay and restructuring, if the ensuing debts are not waived or repudiated, and if its population is not continuously to shrink in the longer-run, then domestic product must grow after  $t = \tau$ . Even then (with  $\alpha > 0$ ) there is no guarantee that continued collapse in the living standards (as represented by national product) can be averted. Given the overhang of debt and the interest thereon, inspection of (10) indicates that, for any particular  $\gamma$  and  $\tau$ , the ultimate longer-run rate of growth in output,  $\alpha$ , must be sufficiently high relative to  $i\beta$ , if permanent decline in living standards is to be averted. These considerations strongly suggest that lenders will indeed have to forget about much of their past lending to such a country.

#### V. THE ZAMBIAN EXPERIENCE: AN OVERVIEW<sup>4</sup>

Around the time of independence in 1964, Zambia enjoyed one of the highest living standards in Sub-Saharan Africa. Directly and indirectly, it depended fundamentally on copper, which accounted for a substantial proportion of national product, of government revenue and for almost all of its foreign exchange earnings. The economy remained in relative boom until 1975, when the price of copper collapsed. In real terms, that price has stayed low since then. At the same time the prices of imports -- energy and other -- continued to rise. As compared to the first ten years of independence, the terms of trade since 1974 moved very much against Zambia, forcing that country into an unprecedented economic crisis. With the advent of substitution away from copper due to modern technology, it seems that the unfavourable terms of trade movement is permanent. Long-term prospects for the economy are rendered more gloomy when it is noted that, at present rates of extraction, its main ore beds are likely to be depleted by around the year 2000.

Initially, and, indeed, for several years, Zambia responded to the terms of trade collapse after 1974 as though it were temporary. Furthermore, by maintaining overvalued exchange rates, and by extending a maze of administrative controls (including cumbersome systems of import licensing and foreign exchange allocation), initial policy responses in many ways only deepened the crisis. At official levels in Zambia, the imperative of fundamental reform, aimed at restructuring the economy away from copper dependence, came to be widely recognised only from around 1983.

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<sup>4</sup> The details in this section are all drawn from Ndulo and Norton (1988).

Compared to an index of 100 in 1974, the terms of trade index had fallen from 49 in 1980 to 36 in 1981 to a low of 28 in 1982. By the early eighties, real per capita incomes had declined by more than 50 percent of their levels a decade earlier. With copper making up about 90 percent of merchandise exports, the collapse in its price was also mirrored in the balance of payments. Foreign exchange reserves became negligible and the country resorted to heavy external borrowing. In spite of that, external payments arrears accumulated. Between 1974 and 1982, and in terms of current dollars, Zambia's import prices increased more rapidly than can be explained by international inflation and oil price movements. This largely reflected increasing markups by exporters to Zambia to cover costs of delays in payment. Thus, by 1982 trade payments arrears imposed significant indirect strains on Zambia's balance of payments.

In 1982, significant arrears on debt service emerged for the first time; yet debt service paid absorbed 38 percent of export earnings. In 1983, debt service due, including IMF repurchases and charges, came to almost 50 percent of export earnings. To those obligations should be added accumulated external payments arrears, which summed to almost 100 percent of export earnings.

For simplicity in exposition, it was assumed in the preceding sections of this paper that all production and imports were for final demand. We must now relax that assumption, and reconfirm the conclusion (in Section II. 2) that the only class to gain in the short-run from a terms of trade collapse in R is capitalists in the AM sector. In fact, the huge deterioration in the terms of trade had a pronounced effect on Zambia's capacity to import, and hence, given very high import dependence of Zambian production, on the level of domestic output as well. The

continued sharp fall in real copper prices, combined with failure to restructure the economy fast, had resulted in a situation in which by mid-1985 the volume of imports (including essential inputs) was about 50 percent below the 1980 level, and 75 percent below the 1974 level. Scheduled external debt service obligations now came to over 70 percent of export earnings, and further payments arrears were accumulating.

By 1985, the chronic shortage of foreign exchange, through its impact on necessary spare parts and materials, had led to massive excess capacity. For the greater part of the year, most companies were operating well below 50 percent of capacity. The rate of capacity utilization had declined, from about 65 percent in 1981, in tandem with the decline in foreign exchange allocations. A June 1985 government policy document noted that out of a total fleet of 6,000 tractors in the country only 38 percent were in working condition. Out of 1,700 serviceable trucks in the private sector, only about 800 were in running condition, and the situation in the public sector was worse. Because of the low level of transport capacity available, it had proved difficult to get crops to market, thereby indirectly accentuating the foreign exchange crisis. Some 50 percent of the fleet of the United Bus Company of Zambia was grounded, thereby impeding access by workers to their places of employment.

Largely in reflection of (misguided) policy responses to the sustained terms of trade collapse, the economy, by the early 1980s, was dominated by a regime of controls that distorted relative prices, in the sense that the signals they conveyed led to inefficient resource allocation. First, price control of goods, and the structure of protection, meant that goods prices were out of line with domestic resource costs. Price control, combined with the protective structure, meant that some goods received negative effective protection. A relative-

ly high (low) effective rate of protection in a sector means that there are strong incentives for resources to be drawn into (away from) that sector. According to a 1984 World Bank study of Zambia, effective rates of protection escalated from low positive rates on capital goods to high rates on import-competing consumables. The study also found that some food products had negative effective rates of protection, while agricultural machinery had low or negative effective rates of protection. Thus the protective structure unambiguously penalised the flow of resources into those sectors. (In this context, recall our earlier conclusions regarding agriculture as a key growth sector in a labour-abundant economy -- such as Zambia -- following decay of the R sector.) Second, the currency was overvalued, which in itself meant that imports were artificially cheap in terms of Zambian kwachas, while exporting was less profitable than it would otherwise have been. Third, interest rates were administratively controlled, leading to a situation in which, given general inflation, real interest rates were negative. By making import-intensive capital goods more attractive than they would otherwise have been, this further accentuated the foreign exchange crisis.

As already indicated, initial policy responses in the second half of the seventies were in the nature of holding operations, more suited to short-run fluctuations in the terms of trade. Realisation that the problems of the copper sector were long-term, and that policy response by way of short-run stabilization was inappropriate, took some years. If markets had been free, the economy would automatically have shown some tendencies toward restructuring away from copper dependence. But the nature of much of the intervention in the agriculture and industry sectors, as well as general macroeconomic, exchange rate and commercial policies, were suppressing such tendencies. Fundamental policy reform, aimed at supporting market forces toward restructuring the economy, was finally forced on the system toward the mid-

eighties. These reforms involved goods price liberalisation and attempts to neutralise the structure of effective protection as between economic sectors, interest rate decontrol, and exchange rate liberalisation through an auction system for foreign exchange. The extent to which the currency was overvalued can be appreciated when it is noted that just before the introduction of the auction system (in October 1985) the exchange rate was 2.35 kwacha to the U.S. dollar; however, following implementation of the auction, the exchange rate quickly depreciated, reaching k8.07 = \$1 in mid-July 1986, and k15 to the dollar early in December.

Restructuring the economy of Zambia away from copper dependence will probably take decades. In the meantime, and in the absence of increased political instability, living standards will have to be maintained at or above subsistence levels. Thus, foreign borrowing will have to continue. Section IV above has focused on some of the problems this entails. However, several bilateral lenders have already made funds available to Zambia on easy terms, and some countries have waived the originally negotiated interest payments -- as, it seems, must inevitably be the case in the absence of outright debt repudiation by Zambia.

#### APPENDIX

Differentiation of equation (5) in the text gives

$$d\tilde{Y}/dt = -\gamma e^{-\gamma t} - 1\beta + 1\beta\tilde{Y}$$

Hence,  $d\tilde{Y}/dt - 1\beta\tilde{Y} = -\gamma e^{-\gamma t} - 1\beta$

Multiplying both sides by the integrating factor  $e^{-1\beta t}$  implies:

$$d\tilde{Y}e^{-i\beta t}/dt = -\gamma e^{-(\gamma + i\beta)t} - i\beta e^{-i\beta t}$$

Integrating, we find that

$$\tilde{Y}(t) = \gamma e^{-\gamma t}/(\gamma + i\beta) + 1 - Ke^{i\beta t}$$

where K is a constant. Setting  $\tilde{Y}(0) = Y(0) = 1$  determines  $K = \gamma/(\gamma + i\beta)$ , which implies equation (6) in the main text.

The derivation of equation (10) is similar to that of equation (6). Using the integrating factor  $e^{-i\beta t}$  as before, (9) implies

$$(*) \quad \tilde{Y}(t) = \alpha A e^{\alpha t}/(\alpha - i\beta) + 1 + B e^{i\beta t}$$

The parameter B in (\*) can be definitized by equating equations (6) and (\*) for  $t = \tau$ , yielding

$$B = \{\gamma/(\gamma + i\beta)\}[e^{-(\gamma + i\beta)\tau} - 1] - \alpha A e^{(\alpha - i\beta)\tau}/(\alpha - i\beta)$$

Next, substituting this definitized value for B into (\*), and re-arranging terms, yields equation (10) in the main text.

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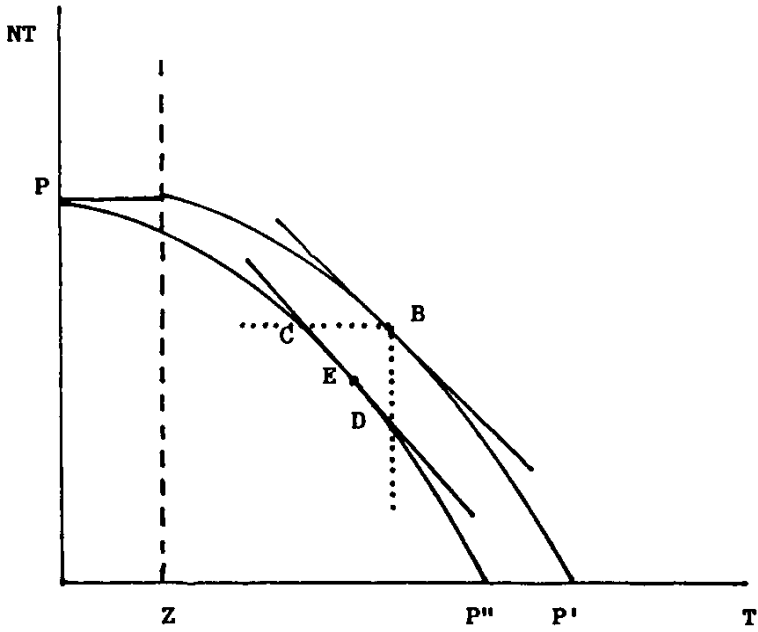


Figure 1

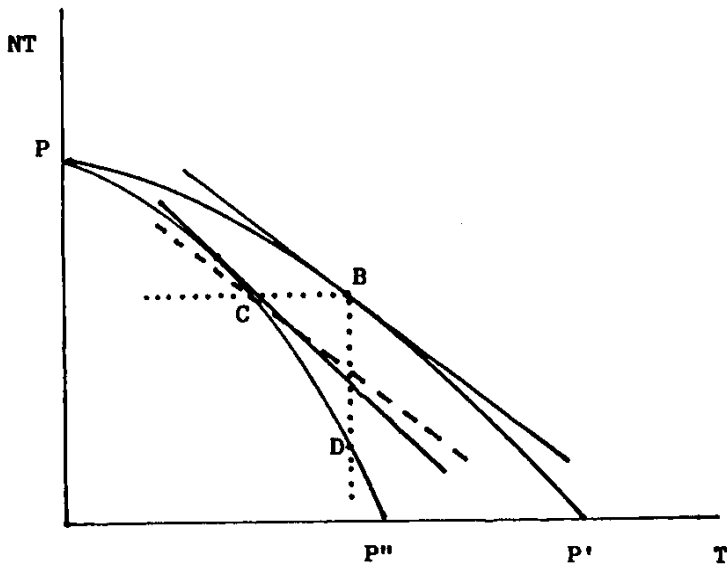


Figure 2

Wage in terms of tradeables

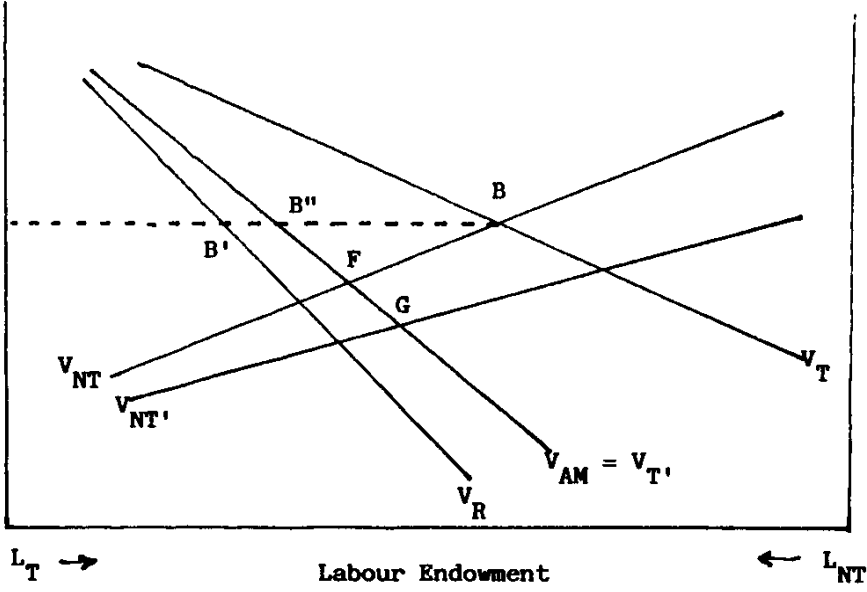


Figure 3

Wage in terms of tradeables

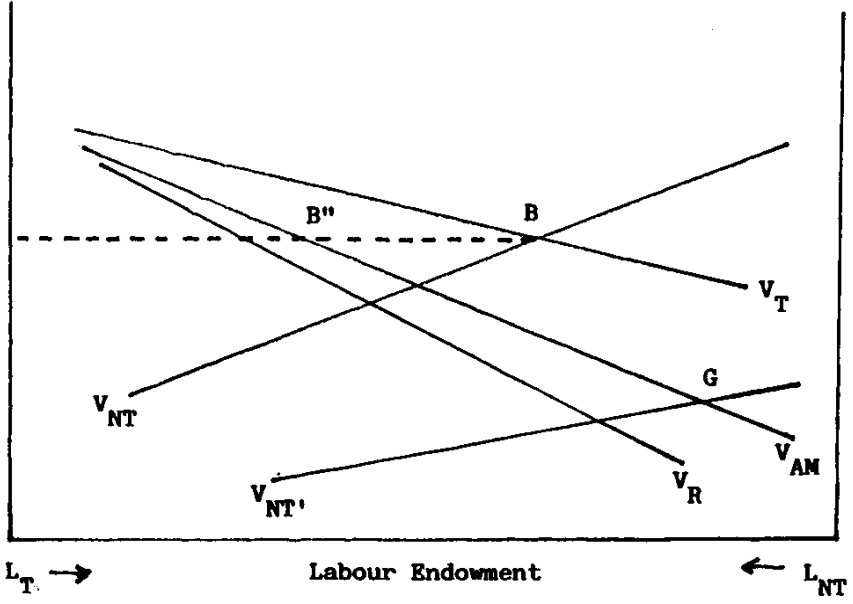


Figure 4

Wage in terms of AM

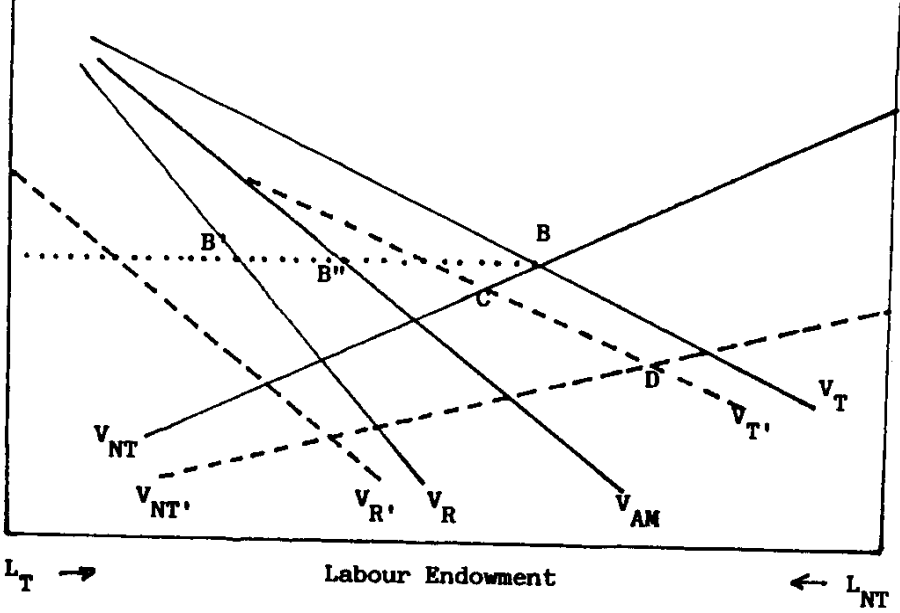


Figure 5

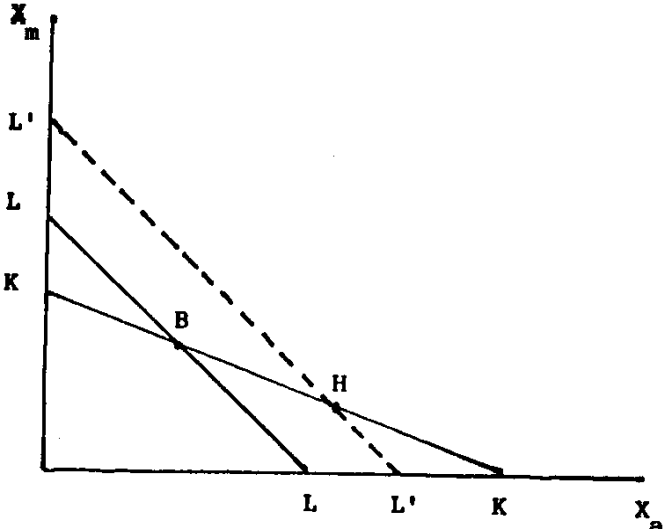


Figure 6a

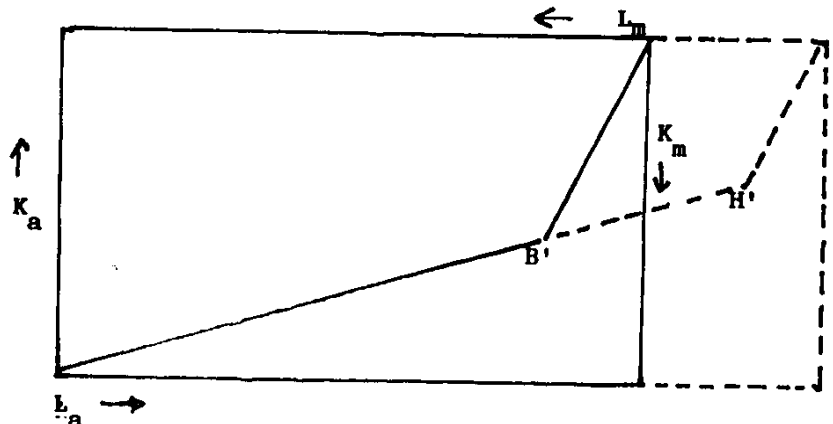


Figure 6b

