Eastern Economic Journal, Volume X, No. 2 April-June, 1984

LOWE, DOBB AND HICKS

Joseph Halevi*

INTRODUCTION

John Hicks coined the term "traverse" in his book Capital and Growth to describe the process of transition from one equilibrium growth path to another. A structural approch to this transition raises the question of whether the several sectors of the whole economy behave in a synchronic or a-synchronic manner.

This question was raised and discussed more than a decade before the publication of Hicks' work in two remarkable articles written by Adolph Lowe. These articles were themselves the continuation of theoretical and empirical research conducted by the author at the University of Kiel in Germany in the 1920s. More recently, the ideas contained in those writings were brought together in a fully fledged theory of discontinuous growth in a book which Lowe titled "The Path of Economic Growth."

The basic structure of Lowe's approach is to represent the economy in terms of reproduction conditions, which is a marked departure from the theory of factor proportions. In his early writings and in the first part of the book, Lowe sets out a stationary model and asks what must happen for such an economy to absorb a sudden increase in the labour force. This question represents the simplest formulation of the traverse problem, which will be discussed in the next section.

Lowe's 1955 monograph was of crucial importance for Dobb's theory of planned growth for underdeveloped countries, today known as the Dobb-Sen model. (Dobb 1960, Sen, 1960). Yet, the way in which Dobb used Lowe's model raises the issue of the links between choice of techniques and structural proportions. This matter is discussed in the third section of this paper where it will be argued that intersectoral relations condition the very choice of techniques. Because of the similarities between the Dobb and Hicks models with respect to reproduction conditions, the latter will also be analysed in that section.

CHANGE OF COEFFICIENTS AND STRUCTURAL PROPORTIONS.

Lowe's 1955 paper presented a model based on strict circularity and flexible specificity of production. The strict circularity condition is necessary in order to account for the intersectoral input output relations of the system, which determine the way in which the economy reproduces itself. In this context Lowe identifies the machine tool sector as that branch of the economy which can reproduce itself as well as produce machines for different uses. Hence in addition to themselves machine tools produce capital goods which can only be installed in the consumption goods sector. Flexible

*University of Sidney, NSW, Australia 2006

specificity arises from the dual utilisation of machine tools and from the single use of the machine designed for the consumption sector. To anticipate a point which will be made in the next section, the above mentioned type of specificity is required in order to keep the picture of economic activity as a circular process; ie. if every capital good were specific the only sequence possible would be linear, with no structural feedback.

The basic model starts from the assumption that the system is in a stationary state and it can be formalized as follows. Let K_m, K_I, K_z be the capital equipment in the machine tool, investment and consumption good sectors, respectively. The stocks K_m and K_I are physically homogenous and K_z, which is the result of the output generated by K_I, is heterogenous vis a vis the rest of the capital stock since it can produce only items of consumption. Each sector is vertically integrated, i.e., it produces its own raw materials. Moreover, the output of each sector consists of only one type of commodity, so that, for instance, the consumption good can be represented as corn, and the investment good as tractors, while machine tools constitute the equipment necessary to produce tractors as well as the means of production which are needed to reproduce those machine tools themselves.

Let α β γ be the output coefficients of the capital stock in each sector, u the uniform rate of depreciation, M, I, Z the respective outputs and a, b, c the labour coefficients for each unit of output in the respective sectors. Under stationary conditions we have:

$$(1) \qquad M = \alpha K_m = u(K_m + K_I)$$

$$(2) \qquad I = \beta K_I = uK_z$$

$$(3) \qquad Z = \gamma K_z = z(\alpha M + bI + cZ) = (\gamma/u)\, I$$

The per capita rate of consumption is z defined in Sraffian terms, i.e. as being above subsistence.

The same structural relations would hold in the case of a uniformly growing economy, provided we add the increments in K_m, K_I and K_z to eqs. (1) and (2). Given the coefficients of production, if the economy experiences growth the rate of per capita consumption z will be lower than in eq. (3). Hence the state of the economy described by eqs (1), (2) and (3) corresponds exactly to what the late Joan Robinson termed a state of bliss; in this situation there is no longer any objective need for capital accumulation. (A similar line of thought is inherent in Keynes' recommendation that capital goods be made so abundant that the marginal efficiency of capital is reduced to zero, which leads to the disappearance of a rate of return on accumulated wealth.)
From eqs. (1) and (2) it is inferred that:

$$(4) \qquad \frac{M}{I} = q = \frac{u\alpha}{\beta(d-u)} \quad \text{implying:} \quad \frac{dq}{d\alpha} < 0; \quad \frac{dq}{d\beta} < 0$$

$$(5) \qquad \frac{Z(1 - cz)}{(z)} = aM + bI$$

Equation (5) formed the basis for Dobb's analysis of the choice of techniques in a planned developing economy. It states that employment in the investment industries is determined by the surplus in the consumption sector, divided by the per capita rate of consumption z. A lower z, however, does not increase aM+bI ipso facto, but rather creates the conditions for such an expansion because a smaller proportion of machine tools has to be allocated for the production of equipment-producing means of consumption.

The expression for the rate of per capita consumption now taken as the dependent variable, reads:

$$(6) \qquad z = \frac{x}{aq+b+cx} \; ; \quad \text{where:} \quad \gamma/u = x$$

In Lowe's tightly integrated structural framework z is always a dependent variable, whereas it is a parameter for Dobb. Hence, while Dobb used Lowe's model as the starting point of his analysis, the change in the assumption about z led Dobb to modify implicitly Lowe's basic approach.

From equation (6) it follows that z is positively related to changes in the production coefficients and negatively related to changes in labour coefficients. Yet if, for instance, there is a fall in labour coefficients, only the increase in z will prevent the problem of effective demand for consumption and then capital goods from making its appearance, but it will not prevent the emergence of unemployment. Equipment is fully utilised in a technical sense and the increase in the rate of per capita consumption assures that no shortage of demand for consumers' goods exists, which in turn guarantees no deficit in the demand for capital goods. Nevertheless, there is unemployment. The problem of the traverse begins here with the question of how to absorb the unemployed.

Clearly, the preceeding question is of a social rather than strictly economic nature. The system, as such, is in equilibrium in the goods market and therefore there are no economic forces at work to alter the investment process. It should be stressed that an economy of this kind is not capitalistic since all the productivity increment (fall in labour coefficients) goes into higher wages. The model of the economy is closer to that of a cooperative-Kibbutz in which collective labour works side by side with hired wage labour, but it is the former that enjoys most of the fruits of technological advances.

The assumption of a Kibbutz type of cooperative economy provides a useful basis for the study of the traverse under stationary conditions. It is possible to postulate that, as equipment wears out, its replacement will display lower labour coefficients but unchanged output coefficients. The process is carried out until all equipment is recast, after which every unit of replacement equipment has the same labour coefficient as the corresponding machinery going out of use. If, for the simplicity, we assume labour coefficients to change only in the two investment goods sectors, the size of the labour force in the consumption goods industry is unaffected. From equation (3) we see that the amount of labour discharged when recasting ends is:

$$(7) \qquad U = I\ b - b^* + q\,(a-a^*)\ ;\ \text{where U is unemployment,}$$
where a^* and b^* are the new coefficients

Once recasting is completed and the system settles at the new coefficients a^* and b^*, unemployment is equivalent to an exogeneous one-time increase in the supply of labour to an otherwise fully employed system.

The main obstacle to the absorption of unemployment lies in the division of the labour force between cooperative members and hired workers since it is from within the latter group that unemployment arises. From a structural point of view the terminal equilibrium conditions for the traverse process are, however, already known. The proportions between the sectors, after absorption is completed, remain exactly the same

in all the three equilibrium positions. This is not difficult to verify; given the output coefficients, the ratios M/I and I/Z must be the same in all three cases (see equations (1) and (2)). The traverse process consists therefore in raising the capital stock K_m producing machine tools to the new equilibrium determined by the percentage increase in the employable labour force; i.e. by U/E. Having reached its new required level K^*_m, the machine tool sector will devote all its net output to building up the capital stock in the intermediate sector. As the latter sector's equipment attains K^*_I, it will set in motion the process by which machinery in the consumption goods sector will be lifted to K^*_z. Once all the three sectors have come to the terminal position of full employment and zero rate of accumulation, the rate of per capita consumption z will equal the rate prevailing when recasting was completed. (See equations (6) and (7).)

The obstacles arise from the fact that, in so far as the community is divided into cooperative members, who therefore own the means of production and make decisions about them, and wage labour, it may not be convenient for owners to undergo the hardship of expanding the stock of capital in order to absorb redundant workers. To raise K_m to K^*_m it is necessary to withhold a part or all of replacement equipment going to K_I. The new level of the capital stock in the machine tool sector will be:

(8) $K^*_m = M\{1 + \frac{1}{\alpha}[1-u+\delta(a-u)]\}$; where δ is the coefficient of nonreplacement of capital stock K_I.

As a consequence, the stock of equipment K_I shrinks by δu, causing a transfer of labour from the intermediate to the machine tool sector.[3] Likewise, the stock of capital installed in the consumption goods sector will decline in the wake of the shrinkage of its source of equipment. It follows that the supply of consumption goods will also decline while the economy is set on a path of expansion for both capital and employment.

If we assume that the construction period of every unit of equipment is one time unit, then the increase in employment will take place ahead of the recovery in the output of consumption goods, which causes a fall in z relative to its level at the end of the recasting phase. Indeed, during the whole transition period z will remain below that level. Moreover, any significant fall over time of the labour coefficients increases the pressure on the machine tool sector if surplus labour is to be remployed.

Two cases can be identified out. The first relates to the possibility of raising K_m to K^*_m in just one period by withholding replacement of K_I altogether. This means that the coefficient in equation (8) is equal to one. The second case arises when K^*_m cannot be attained in the single period even when $\delta = 1$. Strictly speaking, the possibility remains of mobilizing part of the equipment which comprises the stock K_I (which is homogenous with K_m), to bring K_m to its new required level. Yet this option implies a decline in replacement equipment flowing to the consumption sector, which will cause a drastic and sudden contraction of consumption goods output.

In all the cases considered above those who control the means of production face the option of either going through a period of reduced consumption in order to expand the stock of machinery necessary to absorb the unemployed, or foregoing a part of their current consumption by diverting it in exchange for "unskilled" services to the unemployed.[1]

In the above framework redundant labour cannot be reabsorbed via a fall in wages. Equipment and labour remain in a strict relation of complementarity even when labour coefficients change. This change is brought about by the installation of new machinery as the old is worn out, so that the economy gradually moves from one degree of complementarity to another but cannot move back and forth without continually

restructuring its equipment. If wages were to remain unchanged by the end of the recasting period, the unemployment caused by the fall in labour coefficients would become worsened as a result of the lack of effective demand for consumption goods. This proposition would be true a fortiori if unemployment had led to a fall in wages.

DOBB AND HICKS.

Maurice Dobb made use of Lowe's stationary model not to analyse the process of traverse but to discuss the question of the choice of techniques under planned development. His main objective was to argue against the theory of factor proportions. This was done by simply postulating that the wage rate will not fall to zero even with an unlimited supply of labour; more specifically, the minimum subsistence wage in industry cannot be the same as in the agricultural sector.[2] Moreover, if the supply of consumption goods is inelastic because of the limited production capacity of the industrial sector, the rate of per capita consumption of the industrial workers, (i.e. what we called z) will in fact become a parameter. From equation (5) we see that if Z and z are given the only way to expand M and I is to chose a technique of production which lowers the labour coefficients a and b.

The three sector division is used by Dobb to discuss the case in which all investment effort is put into the self expansion of the machine tools sector, which is a process that implies a gradual absorption of K_I by K_m (they are homogeneous so that K_I can be shifted to the machine tool sector). Given the limited supply of consumption goods the expansion of investment cannot take place except in the above mentioned way. For z to remain constant under conditions of a given flow of consumption goods Z, the shift in employment must occur only within the investment sector; that is, it would occur through absorption of workers and equipment in the I sector by the M sector, since any withdrawal of labour from the consumption goods sector will reduce the flow of output. The subdivision of the investment sector into two branches therefore becomes necessary in order to account for the distribution of the labour force changes.

Dobb's analysis rests on the assumption that capital goods last forever; the circularity of production is thus broken since the relation between the output of capital goods and replacement requirements disappears. If circularity is maintained, the rate of per capita consumption z again becomes dependent variable. Any shift in the composition of capital stock away from K_I and toward K_m will reduce the rate at which I flows into Z, negatively affecting the rate of per capita consumption. If Dobb's hypothesis about K_I being progressively drawn into K_m were to be applied under conditions of circularity, the outcome would be to halt replacement investment in the consumption sector, with a consequent shrinkage in K_z and an inevitable fall in Z.

We have thus arrived at exactly the same conclusion as the previous section, in which a change in the labour coefficients generated surplus labour, requiring intersectoral shifts with temporarily lower real wages in order to reabsorb redundant labour. The difference consists in the degree of development of the economy under consideration. In the previous case the starting point was already " a state of bliss," whereas now the constraint on productive capacity is a major obstacle to the attainment. Within a framework of circular production, the problem which predominates is the maximum length of time during which a fall in the supply of consumption goods is compatible with the diversion of investment toward the machine tool sector. It follows that the dynamics of structural proportions determines the type of technique in use since these occur only through changes in the composition of investment.

We have seen that Dobb used the basic elements of Lowe's scheme to build a model

in which accumulation is based on a technique of production which does not increase employment in a degree which affects the rate of per capita consumption of the employed population. This treatment capital goods as having limits an infinite lifetime and flexible form the structural analysis to considering only the the composition of the labour force, which greatly reduces the importance of intersectoral proportions with respect to the choice of techniques. However, Dobb's effort does correspond to an objective economic problem, that of guiding accumulation in countries which cannot "afford" it because of their limited productive capacity.[2]

In chapter 16 of Capital and Growth, John Hicks presents a model which, like Dobb's, assumes equipment of infinite life but, unlike Dobb's, makes the growth rate depends exclusively on the growth rate of population. The economy achieves a quasi state of bliss. Accumulation has to provide the whole labour force with the means of production necessary to maintain full employment. The problem of the traverse thus arises whenever there is a change in the growth rate of the labour force, since the output of machinery must be just enough to absorb the additional workers.

If, to use an expression employed by Hicks, the "Principle of Variation" is assumed to be the central tenet in economics, the question of the traverse would not even arise, nor would the problem of intersectoral proportions. As Hicks wrote in 1932: "The marginal productivity theory assumes that a change in the relative prices of the factors will always be followed by some change in the quantities of the factors employed, that is to say, it assumes that technical methods are freely variable. For if that is not the case, it will be impossible to reorganise a business effectively with one unit less of one factor but with the same quantity of the others." (Hicks, 1932, p. 80). Fixed coefficients of production highlight the fact that the economy is stuck with a given set of equipment geared to definite uses, so that changes can take place only through gross investment. Thus, when Hicks cast his argument in terms of a two sector fixed coefficients model, (explicitly acknowledging that when it comes to the utilization of equipment fixity prevails over flexibility) it marks an important change in assumptions used to analyze the economic activity.

In relation to Lowe's system, Hicks's procedure can be assessed, as far as reproduction is concerned, on lines similar to those followed in the discussion of Dobb's approach. The assumption that equipment is of infinite durability is even less legitimate than in Dobb's case. In the latter there is a specifically defined historical circumstance in countries in which growth cannot be facilitated by lowering the already meager consumption standards. This explains Dobb's penchant for a model in which higher accumulation is compatible with a technique of production which is not based on still lower rates of consumption. In contrast, Hicks excludes any historical specificity from his model. The mission of reproduction is therefore particularly serious.

Marx defined reproduction in the following terms: "The conditions of production are also those of reproduction. No society can go on producing, in other words, no society can reproduce, unless it constantly reconverts a part of its products into means of production, or elements of fresh products. (...) Hence a definite portion of each year's product belongs to the domain of production. Destined for productive consumption from the very first, this portion exists, for the most part, in the shape of articles totally unfitted for individual consumption." (Marx, 1977, V. 1, p. 531).

The implications of the absence of circular reproduction emerge in a strikingly clear manner when Hicks's assumption of equipment of infinite durability is applied to Lowe's model under conditions of zero growth. The capital stock in the two investment sectors would be zero in this case, the only equipment in operation being that installed in

the consumption goods sector. Such equipment is absolutely specific in the model, which means that the system is totally incapable of responding to an exogeneous increase in the supply of labour. No machinery could be used for the expansion of capital stock, since there would not be any equipment technically fitted to perform a process of reproduction. By the same token the economy would not possess any means to account for technical change (in the previous section technical change was caused by replacement equipment emboyding lower labour coefficients).

Strictly speaking this problem does not arise in Hicks's framework because his model is based on one homogenous capital good which can be allocated to either the capital or the consumption goods sector. Hence with infinite durability of equipment it is always possible to switch part of the latter back to the production of capital goods. However, in this way structural constraints are virtually eliminated. The only serious obstacle to an adjustment process comes from so large an increase in the influx of labour that a backward switch to the production of capital goods would require a fall in the rate of per capita consumption below subsistence.

The above considerations help put Hicks's model and the shortcomings of his treatment of the traverse into perspective. For Hicks, transition to a higher or lower rate of growth and equilibrium is dependent on the workforce machine ratios of the two sectors. Given a change in the rate of population increase, full utilization and full employment are maintained and the growth rate of capital stock converges towards the new growth rate (determined by the increase or decrease in the rate of growth of population). Hence, at the beginning of each period the proportion of total equipment allocated to each sector must be such that the total capital stock employs the total labour force, even if the latter has increased, more slowly or more quickly than capital equipment relative to the previous period. We can, therefore, write:

$$(9)\quad [N_k v_t + N_z (1-v_t)] (1+r) = [N_k v_{t-1} + N_z (1-v_{t-1})] (1+g);\ r \neq g$$

Where N_k and N_z are the number of workers per machine in the capital and consumption goods sectors respectively; v is the share of capital stock in the capital goods sector over total capital stock; r and g are the growth rate of capital equipment and of population.

Equation (9) states the condition necessary to maintain full employment where the unknown is v_t, i.e. the new distribution of equipment between the two sectors. It is clear that a solution for (9) requires that $N_k \neq N_z$ since:

$$(10)\quad v_t = v_{t-1} + \frac{N_z (1+g)}{N_k - N_z (1+r)} - \frac{N_z}{N_k - N_z}$$

From equation (10) it follows that successive changes in r will cause it to converge to g as long as $N_k - N_z > 0$, i.e. as long as the machinery in the capital goods sector employs more workers than that of the consumption goods sector. This result is known as the "capital intensity theorem" on which the smoothness of Hicks's adjustment mechanism depends.

This result is essentially non-economic because it makes the entire investment process a passive by-product of the technological specifications of the model. Moreover, the most plausible case, specifically, that an already fully employed economy with no spare capacity cannot absorb an increment to the labour force in excess of that compatible with the growth rate of equipment, can only be dealt with within the very

special case of uniform worker machine ratios. In fact, from equation (9) it follows that if $N_K = N_z$, the equation can be satisfied only for r = g, which means that the model economy cannot cope smoothly with a divergence between the rate of growth of capital stock and labour. This situation should be considered as an important, if not general case, though, it is paradoxically brought to light only when the labour-machine ratios are uniform in Hicks's framework.

The following observations can therefore be made: By eliminating reproduction (a) Hicks' model obliterates the constraints arising from the technical composition of capital. (b) At the same time it gets bogged down in a series of special cases arising from the relative labour machine ratios in the two sectors. The latter is the most interesting case because it implies that the economy cannot adjust immediately although it does not preclude adjustment in the future.

The formidable assumption of one physically homogenous machine able to produce everything, with different labour coefficients according to the sector in which it is put to work, lies at the heart of the ambiguities of Hicks's construction. Is it possible to build a model in which the mechanism of adjustment does not depend on whether the worker machine ratio is greater, smaller or equal to that of the other sector? If the answer is affirmative, then the dynamics of investment is free from technological determinism, while the amount of investment is conditioned by the structural composition of equipment prevailing at any one time. Lowe's model supplies the answer to this problem although he did not specifically tackle the Hicksian formulation of the traverse.

In Lowe's model it is absolutely legitimate to assume that M, the output of machine tools, has only one type of labour-machine coefficient. In point of fact, M is physically homogenous and is either used to reproduce itself and/or produce I, the equipment going to form the capital stock in the consumption goods sector. Hence it is legitimate to conclude that each of the identical machines will employ a given crew; likewise each unit of I, physically different from M, will employ a given crew, numerically different from the crew operating M. Since the integral of past M, net of wear and tear, represents the stocks ($K_m + K_I$) and since the integral of past net I is the stock K_z, it follows that the argument holds true also for ($K_m + K_I = K_k$) and for K_z.

This means that in Lowe's framework an equation like (9) in the Hicksian case, is necessarily an inequality (except when r=g) independently of whether the crew operating K_k is equal or unequal to the crew operating K_z.[4] A difference in the labour-machine ratios is not relevant to the system's structural response to an exogenous variation in the growth rate of the labour force in a two sector model. As a consequence, if growth of the labour force declines, unused capacity is bound to appear; in this case the employment capacity of equipment is greater than the total available labour force. Conversely, an increase in the growth rate will make unemployment unavoidable since the employment capacity of machines falls short of the available workforce. The same argument can be applied to technical progress because, as we have seen in the section discussing the basic stationary model, technical progress of a labour saving type can be reduced to an exogenous increase in the labour force.

The transition to a new equilibrium depends exclusively on the institutional characteristics of the system. In the case of a fall in the growth rate of the labour force, excess capacity can lead to a further fall in investment and employment if the economy is a capitalist demand determined economy. In a socialist system, by contrast, the central policy issue would be how to distribute the amount of unused capacity with the objective of avoiding a situation of capital dealth in subsequent period, a situation which can arise from the concentration of unused capacity exclusively in the machine

tools sector. (Halevi, 1981)

4. CONCLUDING REMARKS

The strong point of Professor Lowe's model lies in the elimination of technological determinism in the process of transition from one phase to the next. This is achieved with remarkable simplicity by assuming two capital goods sectors with a homogenous stock and a consumption goods sector with a totally specific stock of machines. The specificity of capital in the latter sector gives rise to a structural lag which can be extended to take into account different production periods between that required for machine tools and that required for building the machine going to the consumption goods sector. Clearly such a distinction is impossible in a two sector model in which equipment flows from a single department of production.

A legitimate question can now be raised as to whether the model presented in Hicks's "Capital and Time", in which each process has an absolutely specific capital good, supersedes Adolph Lowe's work. In "Capital and Growth", successful completion of the traverse process depends on the very special case of the worker machine ratio in the capital goods sector being greater than that prevailing in the consumption goods sector, i.e. it rests on fulfillment of the so-called capital intensity theorem. In "Capital and Time", the traverse problem is analyzed on the basis of the special case of the "simple profile". The simple profile consists of splitting up the process of production into two periods: one in which labour is used to build up equipment and one in which labour is used with that equipment to produce a finished good. Economic activity is therefore seen as a one way avenue moving from inputs (labour) to final demand. Capital equipment becomes associated with working capital; it is, so to speak, a stage in the production of the finished consumption good.

Hicks's elimination of circularity overlooks the need for a special machine producing sector. An implicit critique of this omission is provided by Lowe. "One need only to consider an increase in the aggregate demand for coal, that is growth, in a system in which all real capital is fully utilized. Then we see at once that the critical bottleneck 'in the hierarchy of production' arises in the machine tool stage and that only after capacity has been increased there, can the output of ore-steel-extractive machinery and finally coal be increased". (Lowe (1976, p. 34n)

FOOTNOTES

1. The ample documentation about this fact ranges from Myrdal's famous Asian Drama to the ILO report on poverty and landlesness (Myrdal 1968 and ILO 1977). A cogent critique of the factors proportions approach was developed by Kaldor. (1975)

2. Michael Kalecki argued against Dobb on the grounds that the model becomes irrelevant if labour productivity rises at a given rate as a result of technical progress. But the Dobb-Sen model is aimed precisely at those cases where the limited productive capacity also limits the rate of technical progress. Another criticism by Kalecki is however closer to the type of argument we developed along Lowe's lines. Kalecki points out that to raise the growth rate through an increase in the capital output ratio the share of accumulation over total output must rise more than the capital output ratio. From the angle of Lowe's model this raises the question of whether the composition of investment can be changed to meet the above condition. See Kalecki (1972, ch 10).

3. If $(a\alpha)^* < (b\beta)^*$ then the shrinkage in K_I will lead partly to a transfer of labour to operate K_m and partly to an additional increase in unemployment. Since however K_m and K_I are formed by the same type of machines it is necessary to assume that $a\alpha = b\beta$ $(a\alpha)^* = (b\beta)^*$.

4. Equation (9) in the Hicksian case can be rewritten for Lowe's model in the following way: Since $K_k = K_m + K_I$ we write $K_m/K_k = V^*$ and $N_m = N_I = N_k$ (workers per unit of capital stock in the two investment sectors and N_z, workers per unit of capital equipment K_z in the consumption goods sector) Hence:

   (a) (a) $\{K_k[N_k V_t + N_k (1-v_t)]+N_z K_z\}(1+r)=(1+g)\{K_k[N_k V_{t-1}+N_k(1-V_{t-1})]+N_z K_z\}$

   The left hand side of equ (a) represents the way in which the labour force has to be distributed after capital stock has grown by r. The coefficient v_t is the unknown and it is entirely a matter within the capital good sectors. The right hand side of equ (a) represents the growth ofthe labour measured in terms of employment capacity of capital stock reckoned at the beginning of the period. Full employment equillibrium means that the equality between the two sides is maintained. In both sides K_m and K_z in the quantities at the beginning of the period at the end of which capital would have grown by r and labour by g. Now it is easy to see that it is not possible to satisfy eq. (a) except when r = g. Equation (a) reduces to:

   (b) (b) $(N_k K_k + N_z K_z)\ (1+r) = (1+g)\ (N_k K_k + N_z K_z)$

   Which is satisfied only when r = g independently of whether $N_k \gtrless N_z$.

   *all V's should be read as small v's.

5. Elsewhere I tried to argue that in a socialist setting central planning is a necessary but not sufficient condition for adjustment (Halevi 1981).

References

Dobb M. (1960); An Essay on Economic Growth and Planning Routledge and Kegan, London.

Halevi, J. (1981); "The Composition of Investment under conditions of Non Uniform Changes", in Banca Nazionale del Lavoro Quarterly Review, June.

Hicks J.R. (1932) "Marginal Productivity and the Principle of Variation" in Economica, February.

Hicks J.R. (1975) Capital and Growth Oxford University Press, Oxford.

Hicks J.R. (1972) Capital and Time, Clarendon, Oxford.

ILO (1977) Poverty and Landlessness in Rural Asia, Geneva.

Kaldor N. (1975) "What is Wrong with Economic Theory?" in Quarterly Journal of Economics, August.

Kalecki M. (1972) Selected Essays on the Economic Growth of the Socialist and the Mixed Economy Cambridge, U.P. Cambridge U.K.

Lowe A. (1952) "A structural Model of Production" in Social Research, Vol. 19 Lowe A. (1955) "Structural Analysis of Real Capital Formation" in Capital Formation and Economic Growth ed by M. Abramovitz, Princeton University Press, Princeton.

Lowe A. (1976) The Path of Economic Growth Cambridge U.P. Cambridge U.K.

Marx K. (1974) Capital Vol. I. Progress Publishers Moscow.

Myrdal G. (1968) Asian Drama, Pantheou New York.

Sen A.K. (1960) Choice of Techniques Basil Blackwell, Oxford.