

SOME ISSUES IN THE CONTROVERSY
IN THE THEORY OF CAPITAL

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CHAPTER I

1.1 Neoclassical economic theory had developed as a conscious reaction against the earlier classical school. The former is characterized by its emphasis on demand as representing utility to consumers, while the latter by emphasis on production conditions, for explaining causal influences determining values of commodities and distribution of the net social product.

The simplest neoclassical model of exchange postulated a given initial endowment position of various individuals with respect to the stock of existing goods. The focus then is on the determination of the optimum allocation of goods through a process of market exchange. This has nothing to do with production of goods. The essential concepts involved are :

- (1) the notion of "marginal utility" - pre-supposing continuous differentiable utility functions.
- (2) the notion of substitution among goods as prices vary - pre-supposing convex differentiable utility functions,
- (3) explanation of prices as "scarcity indexes" and hence optimal allocations of given resources.

To extend this model to embrace production, concepts had to be developed with respect to the phenomenon of production which were parallel to the ones developed for the above model with wealth as a stock - marginal productivity, substitution among factors, the treatment of factor prices analogous to commodity prices, the existence of a production function in terms of the factors of production, etc.

This analysis was on the basis of a given stock of resources - factors of production. Causation was seen to run from consumer preferences to the market for final goods; from there to the markets for producer goods and to "primary" factors of production. There was a distinction between produced and non-produced goods; the latter included land and labour, the former intermediate, i.e., capital goods.

One could now make a distinction between the short run and the long run. In the short run the stock of factors, produced and non-produced, was inflexible; it could be taken as given. Final goods' prices and factor prices could then be taken as being determined by consumer preferences and production conditions.- the above model of exchange was relevant here.

But in the long period the supply of resources could be considered as variable - or responsive to prices. Thus in the long run demand and supply together determined the price and quantity levels through their mutual interaction, depending

upon the degree of responsiveness of each to the price level.

1.2 Neoclassical economists thus integrated the problem of value and distribution into a single one of the pricing of various goods and resources in a 'general equilibrium' framework. But now the problem of the level of aggregation at which to operate became important. At the micro economic level each category^{of} physically identical goods could be considered as a separate factor input - machines of various technical specifications, labour with different skills, lands of different fertility and crop specificity, etc., could be treated separately, each being measured in its own technical unit. Then, given perfect competition in each market, the marginal principle of cost minimisation would ensure that each production unit would operate, in the long run, at a position of minimum cost, and each resource would be paid an equivalent of its marginal product. The whole of economic activity hung in a balance determined by consumer preferences for final goods, and subjectively defined factor supply schedules of individuals.

This picture had two essential features. It was atomistic in nature; each individual's motivations were given prime importance in the analysis. And secondly, it had an air of being free of institutional and historical conditions and influences. This supplied the reason for the plea for *laizzes faire*. (See Note I)

Much more ambitious was the attempt to make operative the same set of arguments to show that at a high level of

aggregation, the distribution between three basic categories of factors, viz., land, labour and 'capital' could be explained in terms of their respective marginal productivities being equal to the rates of rent, wages and profit (interest).

Economists had always considered the explanation of these three classes of income important. Their analysis can be traced back to the Ricardian model for the analysis of rent. Ricardo had made a distinction between rent at the extensive and at the intensive margin of cultivation. The latter formulation was well suited to the neoclassical approach.

Assume that land and labour are the only factors of production. The given technology may permit many proportions in which labour and land may be combined to produce the single commodity corn. Output of corn per head falls as the number of men employed per acre rises (beyond a certain level). The stock of the two resources is given in the economy. The marginal principle of resource allocation then affirms that the higher the real wage (in terms of corn) the smaller the number of men employed. If unemployment exists, competition among workers bids the wage downwards to raise employment. In the case of excess demand for labour, competition among employers bids the real wage upwards to allocate the given supply of labour among employees. The wage stabilises at a level corresponding to the marginal productivity of the given

labour force employed on the given piece of land.

If a linearly homogenous production function in labour and land is postulated. Euler's theorem enables one to show that rent per acre will be equal to the marginal product of land. Thus rent and wage depend upon technical conditions alone. An institutional framework where labourers hired in land would lead to the same result as when landlords hired in labour. Free competition in production enables optimum allocation of resources since the marginal product of labour is the same on each acre. A reshuffling of labour could not increase the product. One can then consider supply schedules of the two factors instead of a fixed stock of each to get a long period analysis of equilibrium, based on a demand and supply analysis. This will be called the "primitive model". This was not a reflection of reality. It aimed to show only that laws of distribution are independent of the form of society.

1.3 All the problems in the theory of capital, and the debates concerning it, stem from the attempt to integrate 'capital' as a third important factor of production alongside land and labour in the above analysis and to place profit (interest) as a third primary category of income along with rent and wage.

The central doctrine was that "wage equals the marginal product of labour", derived from the marginal principle of

cost minimisation. If a parallel in terms of interest and capital could be provided one could maintain that "what a social class gets is what it contributes to the general output of industry" (Clark). Capitalist institutions of private property and wage labour could then be secured from Marxist charges of exploitation of labour by capital. This was the motivation of what is called the 'vulgar' economics. (Refer Note II).

The main requisite condition for such an extension of the primitive model is that one should be able to reduce the diverse physical capital goods into one homogenous quantity, which must be independent of the rate of profit itself. This quantity would then qualify to occupy one of the dimensions of a "production function" along with labour on another. (Refer Note III).

1.3.1 Clark's conceptualisation of capital as a "permanent" metaphysical entity or fund, capable of assuming particular physical forms and capable of transmigrating from one concrete form to another, was an attempt in this direction. But it could not be rigorous for lack of a quantifying principle.

Bohm Bawerk's attempt to find an index of capital magnitude in the "period of production" was more sophisticated in that it attempted quantification. The period of production was defined as the average period for which labour was invested (uniformly over time) in a multistage process of production of

a final good. The integration of capital into the earlier analysis then depended upon two main considerations :

(a) A successive lengthening of the period of production (an increase in the amount of capital) met with diminishing increments of output. (b) Individuals 'irrationally' discounted future satisfaction as compared with present satisfactions of equal magnitude.

These two elements thus constituted the demand and supply sides respectively of the capital market. The demand side was couched in terms of technical limitations of production for the future; the supply side consisted of a subjective undervaluation of future goods which limited the supply of capital to produce for the future. The rate of interest then adjusted to achieve a balance of these two elements.

His theory of capital and production in itself was a significant advance over earlier theories since it afforded insight into certain aspects of capital accumulation. Its major significance was its emphasis on the time dimension involved in the process of investment and roundabout production. The monotonic correspondence between a longer period of production and the larger amount of capital involved (and thus between a longer period of production and the lower rate of interest (or profit) in his theory of interest) was however a result of the restrictive assumption of a uniform application of labour through time, and (what amounted to) a weighting of

labour inputs by simple interest rather than compound interest.

His theory of interest determination was dependent upon subjectivism in the true neoclassical spirit - its adequacy was dependent upon the adequacy (or validity) of the wider theory of pricing and distribution based upon consumer preferences and production conditions.

Abstracting from land, the neoclassical theory of distribution then consisted of ^{an} explanation of factor prices in terms of demand and supply, demand for goods and supply of factor was based on subjective preferences (utility in consumption, disutility of work effort, abstinence or systematic undervaluation of future satisfactions.) The supply of goods and demand for factors was dependent upon technical or productivity conditions. But it was subject to the restrictive assumptions already mentioned above.

1.3.2 It was Wickcell who developed the concept of 'dated labour inputs' in an attempt to get round these restrictive assumptions. His analysis in terms of the marginal productivity of dated labour inputs revealed problems with the concept of aggregate capital. He nevertheless persisted with the view that the concept was useful.

Wickcell assumed that a labour input of any date, past as well as present, contributed separately to production. If all inputs other than that one are held constant, increasing it increases output. Thus he pointed out that interest is

possible because of the difference in the marginal productivity of 'saved up labour', as compared with that of current labour. All capital could "ultimately" be resolved into previously done labour. But the fact that this is 'earlier' labour is "sufficient to justify" the establishment of another category of means of production. The ratio of the marginal products of labour of two different dates can be shown geometrically by putting them on different axes. The slope of an equiproduct curve at a point would show this ratio. The labour inputs of different dates can be substituted for each other in varying the technique.

Now, as more capital is created, (more current labour is devoted to future rather than current production), the marginal product of the now lesser current labour available for current production rises. The increased productivity would thus accrue partly to current labour. A decrease in the difference between the marginal product of capital and of labour would result in an increased wage, and a decreased rate of interest.

The marginal productivities of inputs of various dates must stand in a particular relationships with each other. For example, if the rate of interest were 5 per cent, the marginal productivity of a labour input of each date must be 1.05 times that of the next date in the future. An addition to the total capital would have to be distributed among dated

inputs in such a way as to maintain the same kind of relationships between their marginal productivities, but now in conformity with a lower rate of interest - say 4 per cent. In general an equal addition of inputs at each date would leave the marginal productivities of inputs of earlier dates too high. More would have to be added to the inputs of earlier dates than to those of later dates to ensure the correct relationships between their marginal productivities. Thus when capital grows, it grows "vertically" as well as "horizontally".

In this analysis, capital was viewed 'genetically'; the law of diminishing marginal productivity is assumed to be satisfied for each of the genetic components (dated labour inputs).

Now a theory of the rate of interest requires that capital be regarded as an aggregate of value. A 'cost of production' measure of value as Walras had suggested was insufficient since it involved interest cost on the capital required to produce the capital goods. The value aggregate had to be traced back to the original primary input-labour. To obtain an aggregate, ^{Wicksell} suggested a reduction of different goods to comparable value terms - All capital goods were to be reduced to their dated labour inputs; these inputs would be weighted by the wage rate and the rate of interest (the wage rate being measured in terms of a final product used as a numeraire). Thus the capital aggregate would be :

$$L_t \cdot w \cdot (1 + r)^t$$

- L_t = labour input of date t periods ago,
 n = number of stages in the (finite)
 intertemporal process of production,
 r = prevailing rate of interest per 'stage'
 or 'period',
 w = the wage rate.

But his analysis of capital accumulation in his circulating capital model showed that an increase in capital with given labour force resulted in an increase in the wage rate. Thus the weights used in the aggregation would have to change. An upward revaluation of the old capital stock would occur, and the old physical capital would assume a different aggregate value because of the different weights attached to the dated labour inputs. New capital was of course evaluated by weighing its dated labour series with the values of r and w prevailing after accumulation had occurred. (In his circulating capital model he failed to consider that the downward pull of the lower post accumulation rate of interest may dominate the upward pull of the increase in the wage rate. But he did later meet the phenomenon where the old capital was revalued downward in his analysis of Ackerman's problem of fixed capital.)(Reading 54)

This kind of a result led him to reject the principle that the rate of interest was equal to the marginal productivity of social capital. The increment in social capital

contained an element of revaluation which foiled that proposition. But Wicksell maintained that : "On the whole the theory of the coincidence of the rate of interest and the marginal productivity of waiting is only applicable as an exact formula on certain abstract assumptions. This is quite natural, for waiting on the part of society as a whole - and frequently on the part of the individual is not a simple quantity but - a complex; "average waiting" as a rule exists only as a mathematical concept, without direct, physical or psychical significance."

Wicksell was thus fully aware of the heterogenous nature of capital goods (constituted essentially of two dimensions - amount of past labour and the time profile of its distribution), and of the significance of intertemporal substitution of inputs. ^{However,} his final statement "But it (the concept of average waiting) should nevertheless be retained as a concise general principle reflecting the essence of productive capital" shows him to be as yet not free of the idea that capital could be regarded as a homogenous aggregate. He thus represented a transitional phase in economic thought.

1.3.3 Some economists (e.g. Hicks reading 21) continued their attempts to discover some method of measuring the total capital in the economy. The crucial issue in the search was that this measure should be independent of the rate of profit in the economy; for it was intended that this magnitude would be used in explaining the rate of profit through the usual neo-

classical mechanism of demand and supply. The confluence of these two forces would determine the rate of interest. In other words the rate of interest was (to be) viewed as the price of capital.

But no one ever found a satisfactory solution to the measurement problem. What then occurred appeared to be most surprising. The neoclassical scheme for explaining the rate of interest (the mechanism of demand and supply of capital) took firm root in the minds of economists; this formulation began to be used extensively in teaching as well as research, and it still dominates the contents of graduate courses today. The measurement problem was either forgotten or pushed aside by adherents of the neoclassical approach.

1.4 Relentless pursuit of the problem (among others) by P. Sraffa finally led to the conclusion that all attempts to measure capital independently of distribution were doomed to failure. The results are succinctly presented in Sraffa's book "Production of Commodities by Means of Commodities". A brief consideration of the relevant parts of his analysis follows.

1.4.1 The economy, in which k commodities are produced, is represented by a set of input-output elements in a $k \times k$ matrix of material inputs, a $k \times 1$ vector of labour inputs, and a $k \times 1$ vector of outputs. The material means of production have to be provided at the beginning of the production period,

and hence a rate of interest is applicable to these. Labour is paid only at the end of the production period when output has been produced. The price equations can be set out as follows.

$$(1 + r)(A_a p_a + B_a p_b + \dots + K_a p_k) + L_a w = A p_a$$

$$(1 + r)(A_b p_a + B_b p_b + \dots + K_b p_k) + L_b w = B p_b$$

⋮

$$(1 + r)(A_k p_a + B_k p_b + \dots + K_k p_k) + L_k w = K p_k$$

A, B - - K are commodities produced and used as inputs in production material inputs are used up completely in a single period. (A_a, B_a , etc. are amounts of A, B, etc., required to produce amount A of good A)

$L_a \dots L_k$ are labour inputs

$$L_a + L_b + \dots + L_k = 1$$

Commodities used as inputs in the production of all commodities are 'basics' others 'non-basics'. There are K equations but unknowns are K-1 relative prices, r and w i.e. K + 1 unknowns. The system would be determinate if either r or w are determined from outside the system. It is assumed that the system produces a surplus over and above its input requirements, so that the maximum rate of profits, R, is positive, and for $0 \leq r \leq R$ all relative prices are positive.

From this system can be constructed a "Standard System", consisting only of basics, by adjusting the proportions of the industries while keeping total labour used by the system the same, in such a way that the 'rate of commodity surplus' is the same for all commodities. This would be equal to R . The net product of the standard system is called a "Standard commodity". This composite commodity has the property of being invariable in value in the face of changes in r and w . If prices are measured in terms of the standard net product then, even for the actual system, the relation between r and w becomes a straight line relation

$$r = R (1 - w)$$

(However if prices are measured in terms of one of the commodities used as numeraire the w - r curve may have any curvature. In a multicommodity system this w - r curve may even change its curvature from being convex to concave and vice versa many times. The slope of the w - r relation would however remain negative throughout.

This analysis is a static analysis for a given technique. No changes in the levels of output are considered. The alterations of proportions to construct the standard system is only a conceptual operation used to "give transparency to a system and to render visible what was hidden". The mathematical properties of the actual system are still preserved inspite of these alterations.

The clarification of what Sraffa calls 'relative price reversals' is a prerequisite for the understanding of switching of techniques.

Consider the equation for commodity A :

$$(1 + r)(A_a p_a + B_a p_b + \dots + K_a p_k) + L_a w = A p_a$$

The inputs A_a , B_a , - - K_a have been used at the beginning of the year with labour to yield A at the end. Labour is paid only when the product emerges, but the means of production must be advanced. Hence the interest factor applying to their terms.

These means of production must have been produced earlier. Thus each commodity input term can be replaced by its own means of production and labour derived from its production equation. Thus the production equation for A can be replaced by the means of production and labour required to produce the means of production required for A and the direct labour required for A. But the labour required to produce the means of production has been applied (paid) at the beginning of the period of production of A and therefore must be multiplied by an interest factor $(1+r)$. The means of production to produce the means of production for A must have been advanced at the beginning of an earlier period. These will therefore earn interest over two periods, and must be multiplied by $(1+r)^2$.

This process can be carried backwards indefinitely. Then the equation of A will consist of a series of labour terms applied at various dates and a commodity residue. The latter can be made as small as required by carrying out the reduction to dated labour as far back as necessary. Thus its influence on the price of A can be made negligible, and it can then be ignored. The remaining labour terms would be of the type $L_{an}w(1+r)^n$ where n is the date at which it was applied. Thus we get the equation for Ap_a as

$$\sum L_{an}w(1+r)^n = Ap_a$$

We can similarly obtain equations for Bp_b -- Kp_b , each constituted of a series of labour terms applied at various dates in the past. This reduces the determinants of the prices of the commodities to the values of r and w. The labour terms L_{an} etc., would be determined given the technique of production. It is known that r and w are inversely related (from the equation $r = R(1-w)$), where R is the maximum value of r.

Now consider the equations for any two commodities, say :-

$$\sum L_{an}w(1+r)^n = Ap_a$$

$$\sum L_{bn}w(1+r)^n = Bp_b$$

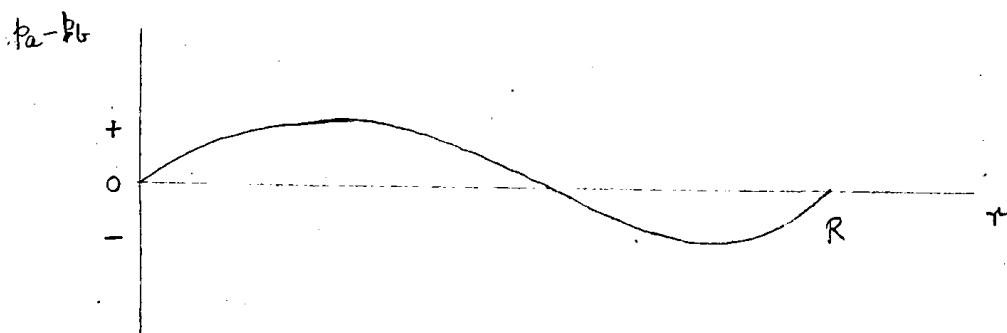
Assume that levels of production of the two commodities were adjusted so that one unit of each were produced. Then we get

$$p_a - p_b = \sum_{n=0}^{\infty} L_{an} w(1+r)^n - \sum_{n=0}^{\infty} L_{bn} w(1+r)^n.$$

(prices are determined by the set of equations and not by the levels of output).

We can consider what happens to $p_a - p_b$ as r is varied from zero to R , and w is varied concomittantly according to the relation $w = 1 - \frac{r}{R}$.

Sraffa proved with a simple example that $p_a - p_b$ may change its sign as various values of r and w are considered as r and w are each varied unidirectionally, but in opposite directions. The number of times $p_a - p_b$ changes sign would depend in a complicated way upon the distribution of dated labour inputs for the two methods.



In Sraffa's own words - "The case just considered seems conclusive in showing the impossibility of aggregating the 'period' belonging to the several quantities of labour

into a single magnitude which could be regarded as representing the quantity of capital. The reversal in the direction of the movement of relative prices, in the face of unchanged methods of production, cannot be reconciled with any notion of capital as a measurable quantity independent of distribution and prices."

1.4.2 It would be better to deal with the question of switching of techniques right away, since this phenomenon is of great importance for later discussion.

The equations of a system together represent a particular technique of production. Even if one of the equations is altered, so that the new equation introduced is not a mere scalar multiple of the one replaced, the whole technique of production is changed. Thus a difference in technique implies a difference in the matrix of commodity inputs.

Assume that an alternative method of production exists for producing good A - A's new equation would be

$$(1 + r)(A'_a p'_a + B'_a p'_b + \dots + K'_a p'_k) + L'_a w = A'p'_a$$

Suppose that the other equations for the rest of the commodities were the same. Also suppose that A were a non-basic commodity (defined as one which does not enter directly or indirectly as a means of production of all commodities, and hence is not a constituent of the standard commodity - which is made up only of basics). The standard commodity for both techniques is thus the same, and prices can be evaluated for

both in terms of it. A similar reduction to dated labour can be carried out for the new, alternative method of production for A. Letting p'_a stand for the price of A evaluated for the new method, we have

$$\sum L'_{an} w(1+r)^n = A'p'_a$$

Given these two methods of producing A, we will be able to calculate $p_a - p'_a$ for various values of r (and w). Since the standard system is the same for both the techniques their maximum rate of profit, R , will also be the same and w and r will again be related according to $r = R(1 - w)$ for both techniques.

As with $p_a - p_b$ earlier, we may get reversals in the sign of $p_a - p'_a$ as r is varied. At any given level of r (and correspondingly w) the method that produces A at a lower price is the more profitable^{one} for the producer who builds the new plant. There may be some values of r (and w) where $p_a = p'_a$. These points correspond to the switching from one method of producing A to the other, and hence from one technique to the other. There may be one or more such points within the range of possible r 's.

If p_a is consistently less than p'_a (or the other way around) one of the methods is unprofitable (ineligible) at all values of r (and w), and it may be ignored.

If A, the commodity having two alternative methods of production, is a basic commodity, each of the two alternative techniques implies a distinct economic system with a distinct R. The standard commodity, though comprising of the same kinds of goods, is also of different composition for each technique. The relation $r = R(1-w)$ is then also distinct; the one having larger R allows a higher r for a given w. There is then lack of common ground for comparison of the two methods.

But two different methods of producing the same basic good can co-exist at those values of r and w where their prices of production are equal. At such points the two economic systems (techniques) will have the same commodity wage and the same system of relative prices.

This is possible, because with k equations and $k + 1$ unknowns ($k - 1$ prices, r, w) one more equation can be added (that of the alternative method of production for A), even though no new product is introduced. Now the system loses its one degree of freedom and the unknowns (all prices, r and w) are completely determined.

There may be one or more switch points between techniques. Since at a switch point the system of relative prices is the same, we can use any one commodity in terms of which to evaluate the two techniques at the switch points.

The two techniques can be viewed as operating at levels such that both require the same amount of total direct labour input. We can then say that the commodities B to K are produced by a given fraction of total labour in both techniques, the remaining labour being used to produce A; two alternative cases may be considered in each of which the remaining labour is operated with only one of the methods of producing A. Since the two alternative methods differ completely with respect to their material and labour inputs required per unit of output of A, one of the techniques will yield a greater product with a given amount of direct labour.

Thus of the two alternative techniques, one (Alpha), yields the same amount of B, C - - K as products, but a slightly larger amount of A, than the other (Beta).

At a switch point, the two alternative total products can be valued in terms of any given commodity (since the relative price system for both techniques are the same). Thus Alpha yields a larger product than Beta (measured in terms of (say) K). The total product of either technique can go wholly for wage payment. Alpha thus yields a larger wage rate per unit of labour when $r = 0$.

CHAPTER II

2.1 The post-Keynesian era saw a resurgence in attempts by neoclassical economists to provide an explanation of distribution between labour and 'capital' in terms of marginal productivities by employing a 'heuristic' device of the well behaved aggregate production function. (Refer Note IV).

The arguments of this function were labour and 'capital'. It was recognised that capital goods are of diverse kinds, but nonetheless refuge was sought in a "malleability assumption". "Capital" is known to assume the appropriate forms in the Marshallian long run. The malleability assumption was thus thought to provide a convenient escape from short run problems of adjustment of the Keynesian type.

Economists tried to see what production function was consistent with data on the wage share, quantity of capital, and quantity of output, (all in per capita terms). Further, assuming neutral technical progress (in the Hicksian sense of maintaining the same capital-labour ratio) they tried to isolate the increases in output per man owing to technical progress, and increases owing to capital accumulation (i.e. due to movement along the production function). Thus this kind of a production function came to be employed in an analysis of economic growth. (Solow, readings 45, 46) A detailed

survey of these attempts is beyond the scope of this write up; it is rather the attack on this kind of a model in explaining distribution which emerged during the last three decades with which this paper is concerned.

The neo-classical position can be stated thus: It is admitted that heterogenous capital goods models analysed by modern linear programming techniques are the appropriate tools for modern capital theory, and in order to understand the pricing and distribution and growth process in the economy. But it is also held that a simple one commodity model could be a useful 'parable' or analogy to the more realistic models. One could explain the trends in income distribution by fitting an aggregate production function to data and still maintain a fair degree of approximation even if this procedure was not rigorous. This boils down to reawakening Clarks metaphysical conception of capital by embodying it in a single all-purpose commodity (called jelly, surrogate capital, leets steel, meccaro, etc., by various authors). Profound truths could be told, it was claimed, by means of this device, about income distribution, patterns of capital accumulation, economic growth, etc.. Four truths of this kind were :

- (1) Lower rates of profit associated with a higher capital per man.
- (2) Lower rates of profit associated with a higher

capital-output ratio.

- (3) Lower rate of profit and higher sustainable steady states of consumption per head (upto a maximum for a given steady state rate of growth),
- (4) Given competitive conditions, the distribution between profit and wages can be explained through a knowledge of marginal products of capital and labour.

The production function satisfying these propositions was called a "well behaved production function" - a fundamental concept of the neo-neo-classical approach.

The attacks launched by Cambridge (England) economists on the neo-neo-classical as well as the earlier neo-classical schools of thought were spearheaded by J. Robinson and P. Sraffa and have gained ground since the early fifties. (In fact the criticisms had commenced even before the neo-neo-classical position had fully crystallised).

2.2.1 Joan Robinson deplored the neo-neo-classical emphasis on the aggregate production function, calling it an instrument of miseducation. (Reading 37) When told to write $Q = F(L, K)$ the student, she complains, is never cautioned about the problems of measuring capital. If the exercise is geared to proving that wage and profit rates are governed by the ratio of employment of labour and capital then a measure

for the latter independent of distribution is an essential pre-requisite.

The same complaint about measurement is not made with respect to labour because, though labour of different efficiencies and qualities exists, labour does have its own technical unit of measurement - labour time - which is independent of distribution. But where capital is concerned, measurement must be in terms of value because net profit is expressed in terms of value and the rate of profit (net profit/capital) is a pure number.

In the first chapter it has already been shown that to obtain a value measure of capital independent of distribution is impossible. This is sufficient ground for rejecting the neo-neo-classical approach.

It can then also be shown that a methodological inadequacy exists in the neo-neo-classical analysis using the aggregate production function. The only two methods of evaluating capital goods is to consider either a) their past cost of construction accumulated at compound interest minus its gross earnings also accumulated from the dates at which they accrued up to the present. b) their future earnings (expected) discounted back to the present at compound rate. Both measures involve the use of the ruling rate of interest and are not independent of it.

Now, arguing on the grounds of the neo-neo-classical production function approach we would say that rates of profits and wages are explained by the marginal productivities of "capital" and labour in a given position of equilibrium. Now consider a movement along the aggregate production function involving a change in the capital - labour ratio. - (Capital is augmented through accumulation.) In the new position different rates of profits and wages must prevail. But now the economic significance of all old capital goods has changed and this entails a difference in their valuation over the situation prior to the investment. Thus the value of a physical capital good is contingent upon the position assumed by the economy on the production function at a given time; it is not independent of it. Each position dictates, on the grounds of the neoclassical theory, a different rate of profit to be used in discounting future earnings or past costs. In that case it is illegitimate to place a factor "capital" on one of the axes and "explain" the rate of profit in terms of its marginal productivity. And it is also illegitimate to talk of trends of income distribution being explained by movements along a production function.

2.2.2 This indicates the significant difference in Joan Robinson's concept of equilibrium from that of the neo-classical one. She regards the latter as containing a "profound methodological error". Her concept of equilibrium is that of a situation where expectations are fulfilled and

where a given rate of profits has been ruling and is confidently expected to continue to rule in the future. This is an imagined position. It has nothing to do with the real world; it is only a means of overcoming "puzzles which arise because there is a gap in time between investing money capital and receiving money profits". In that gap events (like accumulation of new capital) may occur, which alter the value of the numeraire (in an unforeseen way). The fundamental assumption is that of perfect foresight.

The neoclassical concept of equilibrium is that of a position towards which an economy tends to move through time (with its roots in Marshall's description of equilibrium prices and quantities in terms of supply and demand but now applied to the economy's capital as a whole and the rate of interest).

Thus, Joan Robinson questions the possibility of moving from one equilibrium position to another with a different technique of production through accumulation of capital. She asks how, with the necessary change in the rate of profit that accumulation of capital entails, the expectations of the entrepreneurs are to be treated. One is proceeding on the assumption of initial equilibrium at a stationary state. Accumulation of capital is assumed to occur suddenly and permanently. But now an unforeseen fall in the rate of profit would have to occur rupturing the conditions of stationary equilibrium. Capitalists operating on

borrowed funds can no longer earn the interest they have contracted to pay. Those operating their own capital find themselves in possession of equipment they would not have built had they known what rate of interest would be established beforehand. If we assume that accumulation occurs in the expectation of a gradual fall in the rate of interest, the whole analysis becomes complex. There is not a single rate of interest, but a whole complex of rates for different lengths of time, the short rates standing above the long rates. The pace at which the rate of interest (profit) falls is governed by technical conditions. Its pace of fall may vary over its different levels. Thus to be precise, expectations of capitalists must be based on a very sophisticated degree of foresight.

The analysis of accumulation and transition between techniques thus involves immense problems and self-contradictions. Valuation of capital is then different according whether it is based on past costs or future earning prospects. The present stock of goods was constructed on expectations about present events held in the past. These would generally be incorrect and the stock of goods is never in an equilibrium relationship with the current situation.

2.3 Joan Robinson had posed all these questions as early as 1953-54 (reading 37). Her questions had evoked critical responses from Champernown and Swan (readings 9 and 55) both

of whom suggested the construction of index numbers for measuring capital.

They claimed that the problem involved was a mere index number problem. A mere difference in interest-rates, without necessarily corresponding to any difference in production possibilities, can affect the cost measure (in terms of wage units). Now in changing the position on the production function through capital accumulation two things happen together. Physical capital is augmented, and at the same time the whole stock of the already existing capital is revalued due to the change in the interest rate. There is, as Swan put it, a 'change in the value' and a 'value of the change'. It is the latter that was wanted without the former.

Their attempts however came to nought because their solutions involved assumptions which were later proved to be untenable.

Champernown's index construction suffered from the major defect of requiring from elsewhere and already the knowledge of the rate of interest. There is no sense in this procedure for a measure of capital is required in order to use it to explain the rate of interest itself.

Both, Champernown and Swan had assumed that no 'reswitching' of techniques of production occurs as various rates of interest are considered. But the logical possibility

of reswitching was proved later by Sraffa, in 1960.

Since construction of index numbers has been proved to be analogous to chasing a mirage, there is no point in giving a detailed consideration of their attempts. It would instead be better to pass over directly to the phenomenon of reswitching and study its implications for the four truths mentioned earlier in connection with the concept^{of} the well behaved production function.

CHAPTER III

3.1 In spite of the raging controversy about, and ^{the} finally the conclusive proof of, the impossibility of measurement of capital independently of distribution, 'the neo-neo-classical scheme of the well behaved aggregate production function gained wide acceptance in teaching and research in economics.

That this concept and the four truths associated with it are of no use in explaining distribution between labour and capital can be shown by the construction of a simple two good model of the economy based on Sraffa's analysis and demonstration of switching of techniques (presented in Chapter I). Of vital importance are the concepts of reswitching and capital reversing. These will be clarified in due course.

Let the economy consist of two branches. Branch I produces wage good (A), branch II a machine good (C). If we postulate only two industries, one of each type, we have two equations :

$$\text{I } (1 + r)(\theta p_a + \delta p_c) + L_a w = A p_a$$

$$\text{II } (1 + r)(\alpha p_a + \beta p_c) + L_c w = C p_c$$

These equations as a whole represent a technique of production. Each of the equation represents a method or process of produc-

tion of that good θ and α represent the amount of that good of A required in the production of A and C respectively; δ and β represent amounts of C required in the production of A and C respectively. Material inputs are fully used up in the single period of production. L_a and L_c are the respective amounts of labour required. The unknowns are p_a , p_c , r , and w , while the number of equations is two. Since only relative prices are required, we can take either p_a or p_c as the numeraire. So let $p_a = 1$. Now there are three unknowns and two equations. Given either w , or r from outside the model the equations system would determine the remaining unknowns.

The conditions placed on this are that all the unknowns must have positive solutions. This is assured if, for the given input - output technology there exists some positive maximum value of r ($= R$). Then for all values of $0 \leq r \leq R$ we get a non-negative solution for the prices and the wage rate.

Whatever the levels at which the two industries operate, the solutions for p_c and w for a given r would be the same as long as the input-output coefficients (θ/A , δ/A , α/C , β/C) are given and fixed. The prices depend upon the equations and not upon the levels of operation of the industries.

The relation between r and w is an inverse one. This can be seen if the proportions of the two industries are adjusted such that $\delta + \beta = C$. There is no net output of C . Then as long as $A \geq \theta + \alpha$, the system is at least a viable one. It produces a net product of A if the inequality holds. As long as $A > \theta + \alpha$ we will have $R > 0$ thus satisfying the condition given above.

If the whole of the net product (consisting of A alone) is given to profits, r would become equal to R . This can be obtained by solving the equation for $w = 0$ (as it must be if all of the net product is given to capital).

On the other hand the whole of the net product may be given to labour. Let $L_a + L_c = 1$. Then the maximum wage rate would be

$$w_{\max} = Ap_a - (\theta + \alpha)p_a = A_n p_a = A_n \quad (\text{since } p_a = 1)$$

where A_n = net product of A .

Consider the case where, when $r = 0$ the capital-labour ratio is the same for both industries. (Capital in an industry is the value of all its material inputs). In that case a reduction in the wage rate from w_{\max} will release just enough value of the product from each industry to pay profits at the same rate in each. The conditions for equilibrium is that there should be uniform rates of wages and profits in each branch of the economy. In this case

this condition is already fulfilled and no change in the relative price of the machine good C vis-a-vis that of the wage good A need occur to bring about this result. The same holds true as the wage rate is successively reduced till $w = 0$ and $r = r_{\max} = R$ is reached. In this case the relation between w and r , if graphed emerges as a straight line with a negative slope with horizontal and vertical intercepts at r_{\max} and w_{\max} respectively. But it may happen that the technique is such that the capital-labour ratios are different for different industries when $r = 0$. In that case successive reduction in the wage rate from w_{\max} leaves the industry which had a higher capital-labour ratio at $r = 0$ with not enough value released (through wage reduction) to pay profit at a rate equal to that possible in the other. But the condition of uniformity of the profit rates must be satisfied. Thus it will be necessary for the relative price of the deficit industry to rise.

If the C industry has a higher capital-labour ratio at $r = 0$, p_c will rise (with $p_a = 1$). Then the (value of) quantity of capital in the economy, (k) , measured in terms of A, will rise for the given technique.

If the A industry has a higher capital-labour ratio at $r = 0$, p_c will fall ($p_a = 1$) and the total quantity of capital will fall.

The $w - r$ relation will not be a straight line in either of these cases.

The former case is that of a 'negative price Wicksell effect' (k rises as w falls). In the calculation of the rate of profit the numerator is the amount of the net product that is given to capitalists. This is

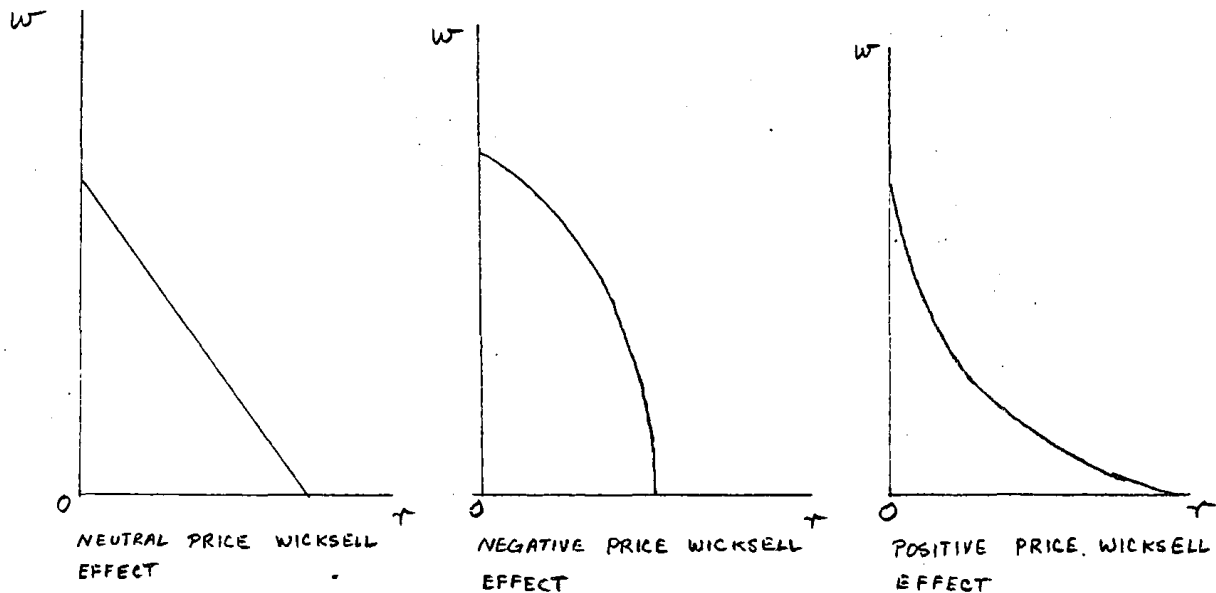
$$A_n - w$$

The denominator will have the value of capital in the economy k .

$$\text{Thus } r = \frac{A_n - w}{k}$$

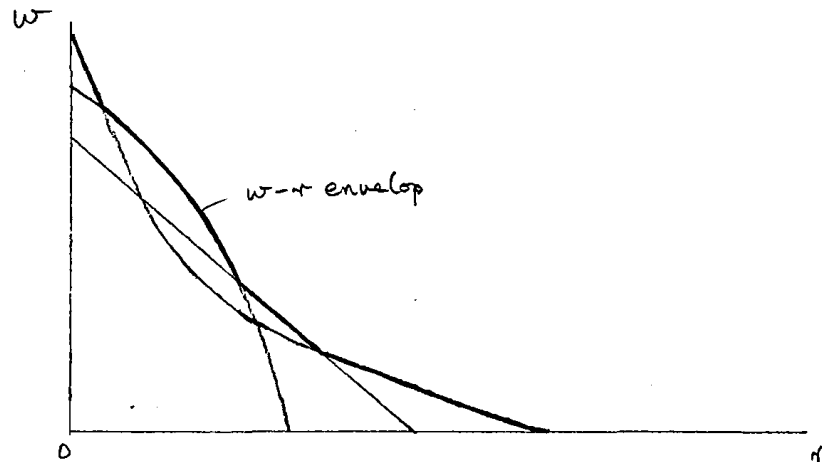
The relation between r and w would be a straight line only if k remained constant as w fell. But because of the negative price Wicksell effect, k rises as w falls, and the $w - r$ curve bends towards the origin (becomes concave to it) as r does not rise fast enough as w falls, to get a straight line relationship.

The latter case is that of a 'positive price Wicksell effect' (k falls as w falls). In this case the denominator in the expression for r falls as w falls, r therefore increases faster and faster as w falls and the $w-r$ curve bends away from the origin (becomes convex to it) as w falls.

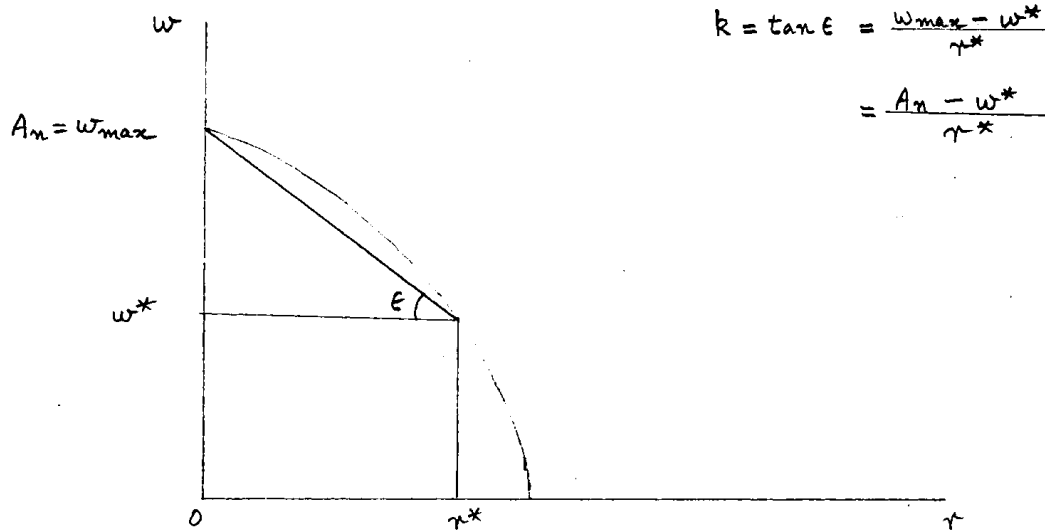


The economy may have many different techniques available to it. Each technique will have its own maximum rate of profit and maximum rate of wages. Since proportions of the activities, for a given technique, do not matter for the price relationships, for given values of r (Samuelson's (see reading 41) non-substitution theorem proves this rigorously), we may conceive that for each technique proportions are adjusted so that, with the given (constant) amount of labour, the net product consists of the wage good alone - which is assumed to be the same (A) for all techniques. Only just enough of the machine good (which is different for different techniques - e.g., wood, iron, copper, tin, etc..) is produced to enable replacement of itself. (It is assumed to be fully used up during the single period of production). Now each technique can be represented by its own wage-profits curve. If all

curves are drawn on the same graph we would obtain an outer, envelope. This would not, in general, be smooth, since the $w - r$ curves which contribute segments to it could have any curvature property. (straight line, convex, or concave). A point of inter-section between two $w - r$ curves is called a switch point. (Recall that, in Sraffa's analysis a switch point occurs at a point where $pa = pa'$, and that at such a point the values of r and w are the same for both techniques - Thus a point where the $w - r$ curves of two techniques intersect can be said to be a switch point.)



Competition would ensure that, given the wage rate entrepreneurs choose that technique which maximises the rate of profit. A simple method of finding the quantity of capital (in terms of λ) for a given technique, for a given $w - r$ configuration, is to find the tangent of the angle made by the line joining the point corresponding to this $w - r$ value on the $w - r$ curve, to the w_{\max} point for that technique, with the horizontal.



This is nothing but a different form of the accounting identity.

$$A_n = rk + w$$

with a straight line $w - r$ curve the value k will be constant and independent of the $w - r$ configuration.

3.2 At this point brief consideration may be given to Samuelson's defence of the well behaved production function, which he attempted in 1962. This was based on an assumption which was too restrictive and hence the model was of little interest. The assumption was that both industries operated with the same capital-labour ratio for each and every technique, thus making all the $w - r$ curves straight lines.

Now if all techniques had straight line $w - r$ curves, any pair of $w - r$ curves can intersect only once. If there were an infinite number of techniques, the outer envelop of

these curves becomes smooth and convex to the origin, and has some special properties.

Each point on the envelop belongs to one $w - r$ curve corresponding to a particular technique. If $\frac{dw}{dr}$ is calculated for a particular point on the envelop we would be calculating $k = \tan \epsilon$ for the particular technique's $w - r$ curve which has contributed that point to the envelop. Since for each technique the labour force is given at unity ($L_a + L_c = 1$), $\frac{dw}{dr} = \tan \epsilon = \frac{k}{L}$ - the capital-labour ratio in the economy using that technique.

Thus the ordinary Marshallian elasticity of the $w-r$ envelop is $E = -\frac{dw}{dr} \cdot \frac{r}{w} = \frac{k}{L} \frac{r}{w}$ = ratio for factor shares in total value of output.

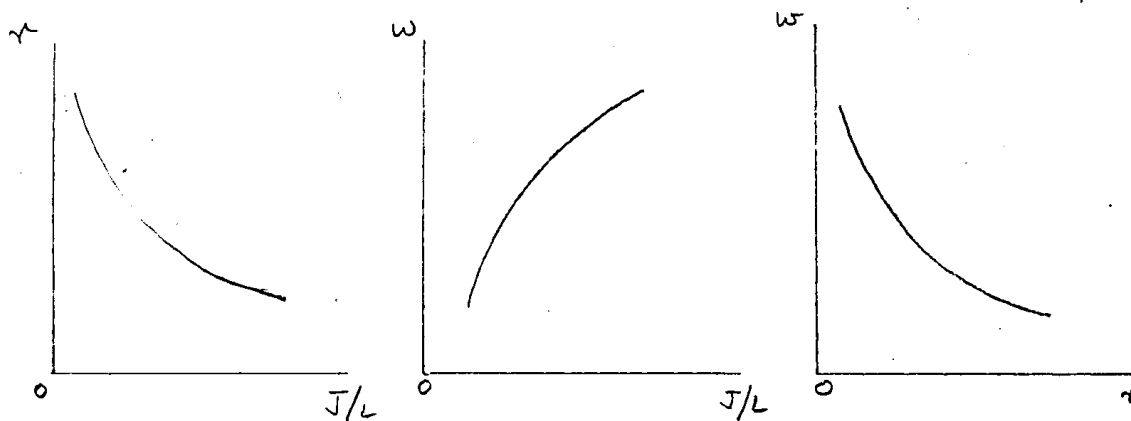
If the curve had corners E is defined within a limited range of values corresponding to all slopes between the limiting slopes to the left and right of the point in question. A limited range of relative shares would be possible depending upon the relative proportions of labour and non-labour inputs that can coexist there.

Upto this point only a "discrete activity, fixed coefficients, heterogenous capital goods" model was considered where "the factor prices can still be given various long-run marginalism interpretations without having to pretend that there is any quantitative aggregate of homogenous capital

that itself truly produces anything".

Now, forgetting the variety of techniques, Samuelson asks the reader to think that labour and physical capital jelly produces a flow of homogenous net national product which can consist of consumption goods or net capital formation, the two being infinitely substitutable on a one to one basis. The resulting production function obeys constant returns to scale and may have smooth substitutability and well behaved partial derivatives which could be interpreted as marginal products,

Only factor proportions count; different real wage and profit rates would have to prevail at each level of capital intensity. The "factor price frontier" can then be derived.



Alternatively : $Q = f(J, L)$ (J=jelly or surrogate capital)
 L=labour)

The cost minimising condition is

$$\frac{dJ}{dL} = - \frac{f_L}{f_J} = - \frac{w}{r}$$

(f_L , f_J stand for partial derivatives of Q with respect to L and J).

The cost of producing one unit of output is

$$p = rJ + wL$$

differentiating we get

$$dp = 0 = Jdr + rdJ + Ldw + wdL$$

Given the condition for minimum costs we have :

$$Jdr + Ldw = 0$$

$$\text{or } \frac{dw}{dr} = - \frac{J}{L}$$

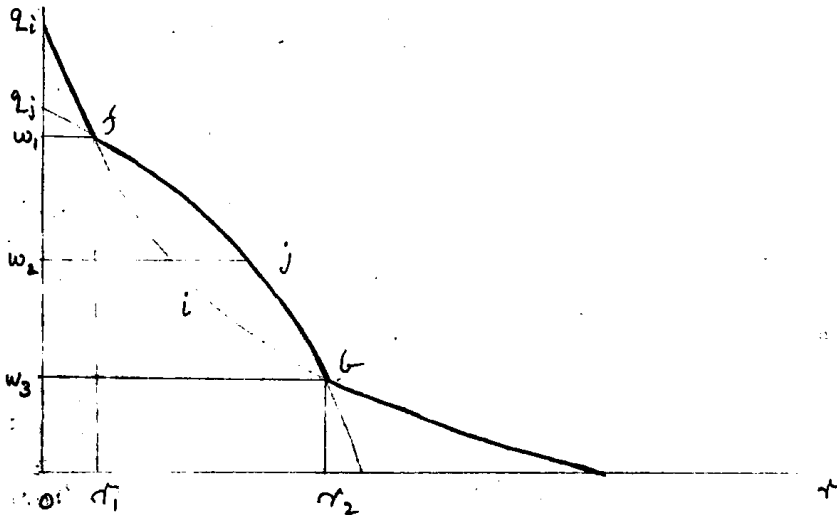
This is the same result as obtained from the discrete techniques heterogenous goods model. (k there = J here)

Thus if we invent the "right fairy-tale" we can come as close as we like to duplicating true reality. "The approximating neoclassical production function in my new concept of the surrogate production function" he declared. The quantity of surrogate (jelly) capital is equal to the slope of the w - r envelop multiplied by the amount of labour at that point.

Joan Robinson later expressed immedulity at the proposition that she well behaved production function provided the neoclassical parable at all she maintained that each point on it was a distinct island - an equilibrium position - and movement over time from one position to another by a given economy was unthinkable since this involved foiled expectations of the entrepreneurs. (Reading 36. Vol.V (see also ^{2.2.2}3.4.6 ahead))

In any case, Samuelson's defence was based on too restrictive an assumption and is not worth a second look. (It warrants at least one look, but only because it indicates the special assumptions that one has to make to derive a production function which is well behaved. Readings 2, 16 and 17 illustrate how surrogate capital refers to a special model of limited interest).

3.4.1 Let us consider an economy with two techniques available to it. Since the $w - r$ relationships may be of any curvatures it may happen that one $w - r$ curve contributes two distinct segments to the $w - r$ envelop. (This could happen even in the case where many techniques are available).



The $w - r$ curves correspond to i and j techniques; they intersect twice at points f and b . q_i and q_j stand for the net output (consisting of good A only) per head for the two techniques, we know that

$$k = \frac{q - w}{r}$$

At $r = 0$ technique 1 yields a higher wage since $q_1 > q_j$.

At the points of their intersection the two techniques have the same $w - r$ configurations.

Therefore at these points technique 1 has a higher value of capital :

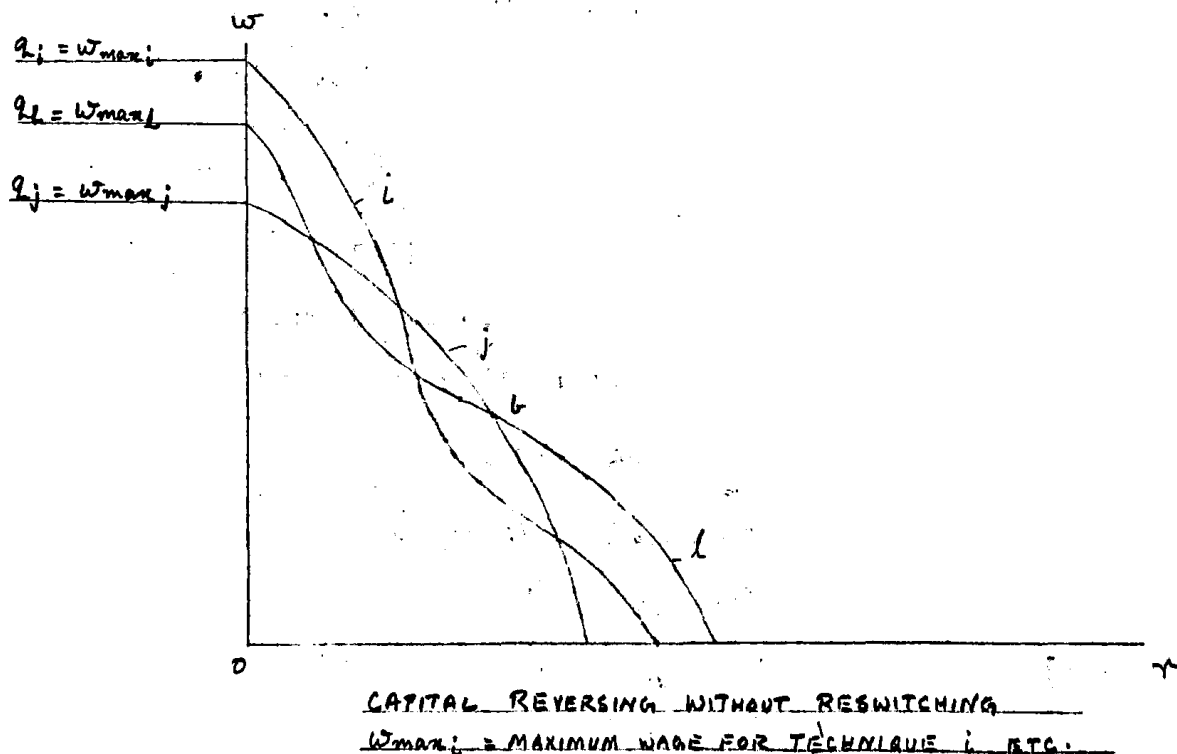
$$\frac{q_1 - w_1}{r_1} > \frac{q_j - w_1}{r_1} \text{ and } \frac{q_1 - w_2}{r_3} > \frac{q_j - w_2}{r_3}$$

The dark line shows the $w - r$ envelop, showing the locus of points yielding maximum w for given values of r . At the switch point b , as the rate of profits is reduced, technique j becomes eligible since it yields a higher profit rate for the range of wage $w_1 < w < w_2$. Thus at this point a technique, with a lower value of capital 'comes in' as the rate of profit is reduced. This phenomena is called capital reversing, and the switch point at which it occurs is called a backward switch. At the other switch point technique i (the one with a higher value of capital) 'comes in' as r is reduced; this is called a forward switch point. The phenomenon of capital reversing contradicts the first truth. (See page 24)

Reswitching (or double switching) is the phenomenon where a technique is eligible at a certain rate of profit, disappears (or is dominated by another) as the rate of profit is altered in a particular direction, and then reappears as

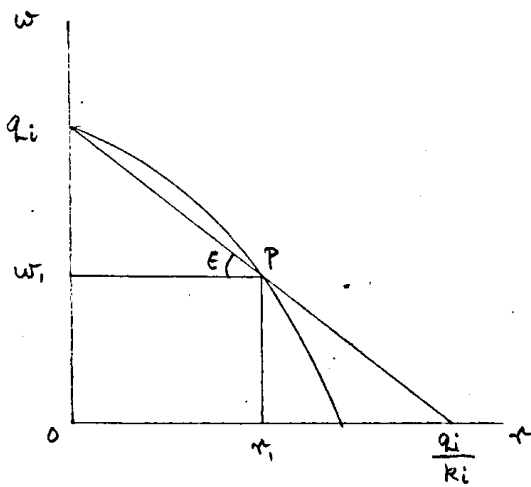
the eligible technique as the rate of profit is further varied in the same direction. (When it is said that 'the rate of profit is altered' one should not understand it as a process occurring over time. The whole exercise is a comparison of alternative positions in a sequence of successively higher (or lower) values of r).

In the case of more than two techniques the phenomenon of capital reversing may occur without their being a reswitching of techniques, i.e., on a $w - r$ envelop switch points like b may exist without any one technique contributive two distinct segments to it. But when reswitching occurs, capital reversal necessarily also occurs. Thus reswitching is sufficient but not necessary for capital reversing to occur. It is the phenomenon of capital reversing which is damaging to the neoclassical parable. It may be noted that Samuelson's special assumption serves to exclude capital reversals. Thus his production function exhibits behaviour in conformity with the four truths. This is easy to see. The reader could himself verify this while going through the arguments given to refute the truths.



Here b is a backward switch point involving capital reversal; there is however no reswitching involved, as each $w - r$ curve contributes a single segment to the $w - r$ frontier.

3.3.2 The second truth can be dealt with as follows. Given



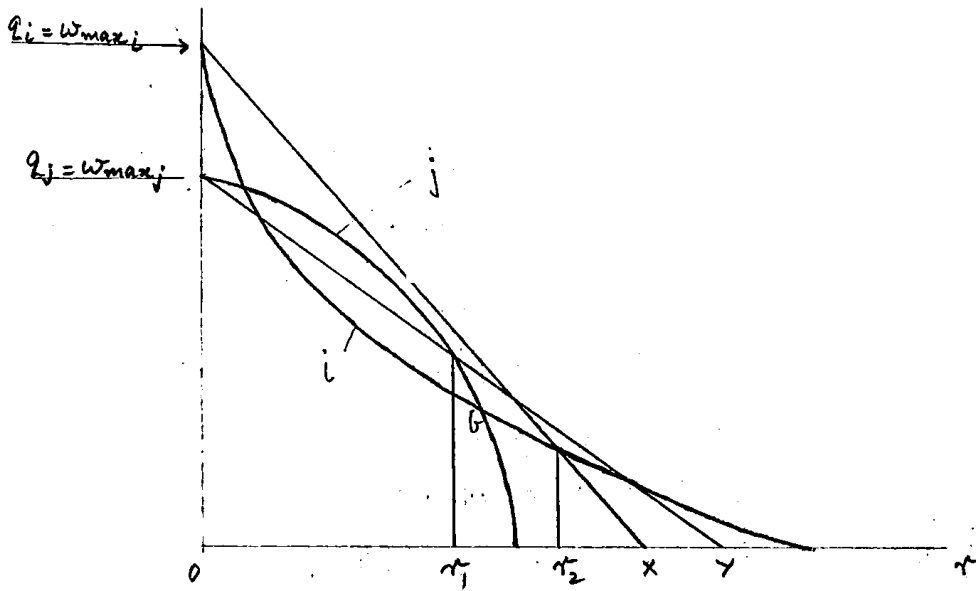
a $w - r$ curve, the value of the output to capital ratio at a point on it is given by the horizontal intercept of the line joining the points q_i (net output per man) and the relevant point (P). This follows from the

relationship $k_1 = \frac{q_i - w_1}{r_1} = \tan \epsilon$

$$\therefore r = \frac{q_i - w_1}{k_1}; \text{ and } \frac{q_i}{k_1} = r_1 + \frac{w_1}{k_1}$$

This equals the distance from the origin to the point q_i/k_1 .

The following occurs in the case of capital reversing i and j are two techniques; b is a backward switch point. At $r = r_1$ technique j is eligible and the output-capital ratio is shown by distance OY . At $r = r_2$ technique i is eligible and the output-capital ratio is shown by distance OX . But



But here a lower r ($= r_1$) is associated with a higher output-capital ratio, i.e. with a lower capital-output ratio, which is contrary to the second truth.

3.3.3 The third truth refers to negative correlation between rates of profit and maximum sustainable rates of steady state consumption per head. A steady state is a condition wherein all elements of the economy, material inputs, labour, and material outputs bear a constant relative size (constant proportions) to each other over time. The economy may be stationary, which involves constant absolute amounts of the elements over time; or it may be growing - which involves proportionate growth in all the elements.

The higher the steady state rate of growth considered, with a given technique of production, the more the amount of

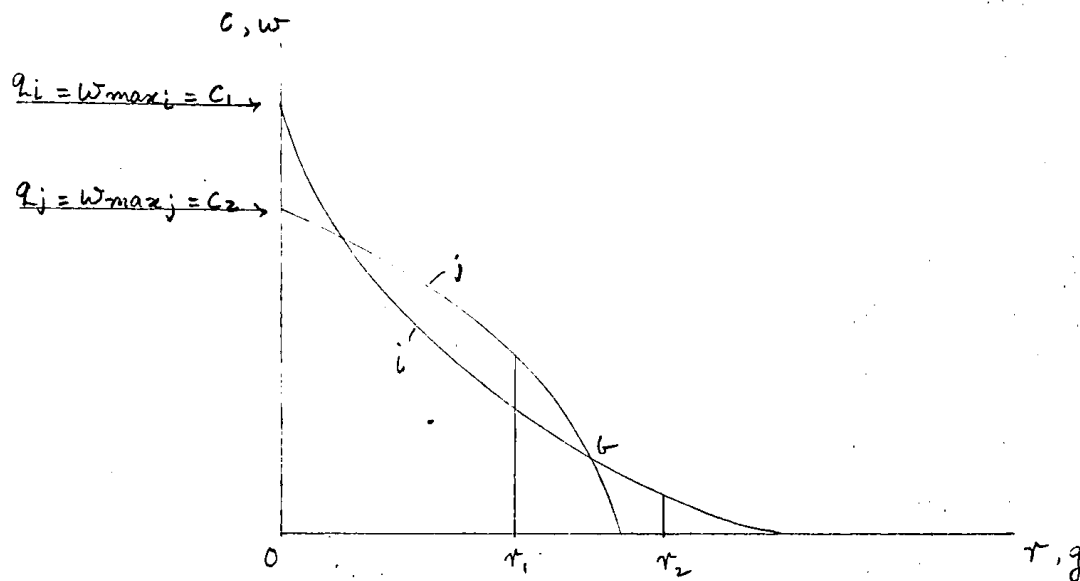
each material item that must be kept aside from the net output of a period for use as input in the successive period; the less, therefore, is the amount available for consumption (see Donald Harris for a complete elucidation of the relationships - reading 57).

It can be shown that the curve showing the trade-off between consumption per head and growth rate for a given technique is identical to the w-r curve of that technique, assuming that per capita consumption is measured in terms of the same (composite) commodity (see CC Von Weisacker - reading 58). (Per capita consumption is the same as the share of the surplus which is consumed since total labour in the economy is unity.)

There is a fundamental symmetry between the categories of the rate of profits and the rate of growth, and between the wage rate and the rate of consumption per man. This is intuitively obvious since both positive profits and positive growth imply that something has to be deducted from the net product and set aside for a particular use - in the one case for paying profits, in the other for investment.

Comparison of the amounts of steady state consumption allowed by alternative techniques must be made at a given rate of steady state growth being common for both. (This must be the basis of comparison since the rate of growth itself is a variable affecting per capita consumption; the question is which

technique allows higher consumption per head, given that both have to 'give up' a certain part of net output at each time to enable the economy to grow at a given rate.)



For the purpose of comparison between techniques, any rate of growth may be taken; the comparison may even be made at a zero rate of growth - where $c = w_{\max}$ for any technique. The diagram shows that at r_1 technique j, with a per capita consumption c_1 is eligible ($g = 0$). At r_2 technique i is eligible with $c = c_2$, ($g = 0$). Thus a lower r is associated with a lower per capita steady state consumption level, which is contrary to the third truth. (See Note V).

3.3.4 The fourth truth is then false a fortiori, since it is based on the concept of a "well behaved production function" of the surrogate capital parable. Now one cannot say that

r is the marginal product of "capital"; income distribution cannot be deduced from the elasticity of the $w - r$ envelop.

3.4.1 Samuelson admitted the inadequacy of the concept of surrogate capital in neoclassical capital theory in 1966.

The simple point is that any capital aggregate is made up of two dimensions, one is the amount of past labour inputs, and the other their time distribution in the past. Their time distribution becomes important because part of the cost of production of a capital good consists of the interest-cost on capital used (advanced) to work with labour; and interest must be calculated at compound rates over the successive time periods until the production process is completed.

Samuelson shows how the early Austrian model of production involved a simplifying assumption of a uniform application of labour through time enabling them to set up a monotonic correspondence between the rate of interest and the period of production - their index of capital quantity. He shows with the simplest of examples that when the assumption of uniform application of labour is relaxed the phenomenon of reswitching is quite plausible. A similar example had already been given by Sraffa in 1960.

3.5.2 Joan Robinson pointed out an interesting nuance in interpretation with respect to the form in which Samuelson

conceded the point about reswitching "He seemed to suppose that if the process of accumulation hit a backward switch, where a lower rate of profit is associated with a lower value of capital per man, the economy would suddenly find itself able to consume part of its capital without reducing its productive capacity". Her point is that ingrained neo-classical habits of thought still led him to confuse a comparison of positions of equilibrium with a 'Wicksell process' of accumulation without technical progress where one 'creeps' along a production function made up of 'leets' and labour. (Reading 36, Vol. V).

Another curious development was the argument over the probability (distinguished from the possibility) of there arising backward switching in reality. The whole argument misses the point that there can be no movement along the 'pseudo' production function; and in reality there is no such thing as a pseudo-production function. The concept is the result of a thought experiment on which each point represents a distinct state of the economy with its own history.

In reality, economies are separated in space, and no two economies have the same technology because of historical and geographical accidents. Inventions and innovations are moreover occurring even as accumulation is taking place and the technique chosen to embody the physical machines produced rarely turn out to be the best choice after the event of

investment. Thus there is nothing like accumulation in a given state of technical knowledge. This idea was made up by the neo-classicals only to give meaning to the concept of marginal productivity of capital. But now it has been shown that such a concept has no meaning.

Samuelson admits in a reply that there was scope for misinterpretation on this point due to ambiguity of English speech and grammar. But he points to his example in the 1966 article where, an economy is shown as shifting from one technique to another and back again and showing that going to a lower rate of interest may involve a disaccumulation of capital rather than accumulation (a case of backward switching or capital reversing). He claims that "No reader has reason to think that the technological relations of the transition are falsely derived there". Further he maintains that it may be legitimately doubted whether "(a) a planned economy would have the wit to follow such an intertemporally efficient, warrantable path, or, withdrawing doubt about planned systems, whether (b) a competitive market system will have the foresight, or the perfect future markets to approximate in real life such warranted paths that have the property that if everyone knew in advance they would occur, each will be motivated to do just that which gives rise to them."

At this point Joan Robinson seems to have given up hope of any reconciliation. "He continues to use his

construction to describe a process of accumulation that raises wages, alters technology (techniques) and changes stock of inputs made, say of wood into one made of iron and then into copper". To her, this methodology is unacceptable, but "Prof. Samuelson assures us that it is quite all right. The argument rests on a difference of opinion about a purely logical point."

CHAPTER IV

4.1.1 These debates led to some writers (e.g. Solow, reading 48) dissociating marginal productivity relations in distribution theory from the concept of the aggregate production function. (See Note VII) Existence or otherwise of the latter has nothing to do with factors receiving their marginal products given an economy is in equilibrium. Marginal productivity relations in distribution must hold in equilibrium as a matter of logic, as long as businessmen are profit maximisers. No reference need be made to 'aggregate capital' or its marginal product. The logic is that if any factor were not paid its marginal product, a change in its quantity would add more (or less) to revenues than to costs, thus violating the assumption of profit being maximised and the economy being in equilibrium. This argument is linked to the attempt to rehabilitate the notion of the rate of return as a central concept in capital theory.

This rate of return is a technocratic notion, (not identified with observed profit rates or any income category of the capitalist economy) and is independent of institutional arrangements.

The economy produces a single consumption good (or a composite good in fixed proportions). There may be many

primary factors, and the production process may involve prior output of intermediate (capital) goods, and thus require delay periods, fixed or variable in length. A current efficient plan of production extending over n periods is given. (Reshuffling of the currently given stock of primary and intermediate inputs cannot result in more of one output without there being less of some other.) The planner must contemplate neighbouring efficient allocation possibilities.

That the consumption bundle is of a fixed composition is not a serious constraint; efficient allocation implies marginal rates of transformation among goods. For small changes in the plan involving less output now of the consumption good (and consequently more output now of some capital goods resulting in more output of the consumption good in a future period (or periods)) one can calculate the rate of return earned in this act of saving in terms of any one consumption good.

Let currently planned consumption levels be C_0, C_1

.... C_n for the n periods. Now if the planners consider $C_0 - h$ for consumption in period 0, and $C_1 + k$ for period 1, leaving $C_2, C_3 \dots C_n$ unchanged. ($C_1 + k$ being the maximum producible output given that h has been sacrificed in the previous period).

The one period rate of return is $\frac{k - h}{h} = \frac{k}{h} - 1$.

The planners may just as well choose more consumption in period 0, with less in period 1, and the same thereafter. With smooth technology the ratio of return in either direction would be the same. If the technology exhibits constant returns to scale with diminishing returns to particular inputs, the discrete case will show higher rates for decreases in saving than for increases.

The planning authority may have to choose between consumption profiles of diverse intertemporal structures. But it would always have a base (current plan) situation to compare with each of these. All it has to do is to consider all possible future time profiles emanating from the current situation, eliminate the inefficient ones and choose the best ('the most preferred') among the remaining. He is thus considering small variations around some pre-existing situation.

Some alternative consumptions profiles may be difficult to summarise in a single rate of return per period - there may be more than one marginal efficiency of investment for

a single alternative consumption programme. (See Note VIII)

The best procedure is to get on without internal rates of return). "The short-run technologically defined rates of return are the basic material, and all that is necessary can be constructed from them. They need not be averaged into some overall figure". Now, the role played by the stationary state (or the more generally steady state growth paths) is to provide such base situations from which displacements can be made - "either from one stationary state to another, or a slight deviation and back again ... For most problems likely to be faced by the general economist, some natural comparison will present itself." (Solow, reading 48)

In this analysis no mention is made, nor a need felt, for some measure of aggregate capital. If the economy throws up market prices or analysis throws up efficiency prices, the economic goods may be aggregated to yield a value sum. But these are not "capital" in the sense of belonging to the arguments of a production function, and having a marginal productivity. Such a representation (along with the necessary malleability assumption) "makes neoclassical theory easy" (apart from the question of distortion), but it is not essential to it. Neoclassical theory can be built around the rate of return concept - including efficiency price theory and the possible identification with market prices and interest rate.

4.1.2 Solow's attempt to base neoclassical analysis on the concept of the rate of return was further elucidated by him in 1967 (reading 49). He makes the observation that at a switch point where two techniques can coexist and have the same set of relative prices (identical commodities being produced by both), one technique involves a larger amount of capital and yields a larger product - just enough to pay the switch point rate of profits at the corresponding wage rate. The technique involving the larger amount of capital may be the one emerging as eligible at a range of profit rates higher than the switch point rate. But this capital reversal does not matter to him. It only means that in making the transition to the technique eligible at the lower range of profit rates society exchanges increased present consumption for future consumption instead of the other way around. This intertemporal exchange of consumption involves the same (switch point) rate of return; only we have future sacrifice for current benefit in this case.

His next step is to argue that in the infinite techniques case the $w - r$ envelop consists only of switch points. Transition between techniques can thus be achieved as the rate of profit is gradually lowered; at each transition society either gives up present for future consumption or vice versa depending on whether the point is a forward or a backward switch point. But at each transition society would be earning a rate of return on the intertemporal exchange equal

to the rate of profit at that switch point.

The proof that the social rate of return on saving (or dissaving) in passing from one technique to another is equal to the rate of interest at which the two techniques are equally competitive is as follows:

Let R be the social rate of return and let a, b , be two techniques which compete at the rate of interest (profit) r^* .

We know that in steady-state with technique a

$$x = c + ax$$

c = vector of consumption goods

x = vector of outputs

a = matrix of inputs of technique a .

In a steady state with technique b :

$$y = c^* + by$$

c^* = vector of consumption goods

y = vector of outputs

b = matrix of inputs of technique b .

The economy now tries to change from one steady-state to the other (it is a planned economy). To change over in a single period, y must be kept aside out of output x . Then consumption would have to be reduced to \bar{c} . Assume $\bar{c} \geq 0$; otherwise one period is not enough for the change over). The sacrifice in consumption is $c - \bar{c}$, whereas later a

perpetual gain $c^* - c$ will accrue (the sacrifice could be a gain, and the gain a sacrifice if the transition is from b to a). Set $w = 1$ (nominal wage).

We know that at a switch point the relative price systems of the two technologies are the same. Let p^* be the price vector, $p^* = (1 + r^*) p_a + w a_0$

$$p^* = (1 + r^*) p_b + w b_0$$

a_0, b_0 are the vectors of labour inputs for the two technologies. Then the natural definition of the social rate of return is

$$TR = \frac{p^* (C^* - C)}{p^* (\bar{C} - \bar{C})}$$

If only one of the commodities is a consumable good, prices drop out of the definition (the same thing could be achieved if only a fixed composition basket of commodities were consumed).

But -

$$c - \bar{c} = by - ax$$

$$c^* - \bar{c} = (I - b)y - (I - a)x \quad (I \text{ is an identity matrix})$$

Thus

$$TR = \frac{p^* (I-b)y - p^* (I-a)x}{p^* by - p^* ax}$$

$$\text{But } p^* (I - a)x = r^* p^* ax + a_0 x$$

$$= r^* p^* ax + L$$

Analogously

$$p^* (I - b)x = r^* p^* by + L$$

Thus

$$R = \frac{r^* p^* b y + L - r^* p^* a x - L}{p^* b y - p^* a x} = r^*$$

If r_a is the rate of interest at which only technique a is profitable and r_b that at which only b is profitable, he writes

$$r_a \geq R \geq r_b.$$

As the number of techniques becomes larger, the gaps between them shrink, and "every point becomes a switch point".

4.2 According to Joan Robinson (reading 36 vols. IV and V) the last sentence (in quotes) is a false proposition. She maintains that the densest possible spectrum of techniques is one at which there are no two adjacent wage rates with the same technique. Over any stretch of the spectrum there is only one wage rate for each technique, and only one technique for each wage rate - there is no third wage rate between two adjacent ones, which is perceptible and so no intermediate mixture of techniques is possible. (Crudely, at a wage rate of Rs. 500/month, there is one technique which is most profitable, at $w = \text{Rs. } 500.01$ there is another. The two would be equiprofitable at $w = \text{Rs. } 500.005$ - but that is not perceptible).

She says that Solow's demonstration amounts to saying that a switch point is a switch point, and nothing more. (The question is rather about what determines the point at which

an economy settles in equilibrium.) In a discrete case with a limited number of techniques one can imagine investment being made at a switch point with a and b techniques equally eligible; a plant of technique a can be replaced by one of technique b. The return to such an investment would be equal to the ruling rate of profit. But this can go on only to the extent where all 'a' plants have been replaced by all 'b' plants. Beyond that, further investment requires a change of profit rate and so a different rate of return.

In the continuous spectrum of techniques case the argument cannot be held since there are no switch points. At each perceptibly different wage rate only one technique is eligible.

A further criticism is that the argument has been cast in terms of socialist macroeconomic planning. In a capitalist economy, however, the expected rate of profit on new investment depends upon what happens to prices and wages in the future. A projection for the future will show different rates of profit on different investments. Each investor would opt for the line promising the highest rate within his sphere of competence. There is as a result a tendency in the long run (in the Marshallian sense) for the rate of profit to become equal in different lines. The planner has no reason to bother about the expected rate of profit, though he may have worked out some kind of marginal productivity. The capitalist, however, cares about the rate of profit, not about

marginal productivity.

An even more fundamental point pressed by Joan Robinson (as has already been explained in Chapter III) is that in the discrete or continuous cases the argument is besides the point. There is no investment going on in any of the 'islands of equilibria in order to achieve capital "deepening". It is just a comparison of stationary (or steady) states.

4.3.1 The attempt by Solow to try to cast the rate of profit as equivalent to a rate of return (on sacrifice) has been further criticised by Pasinetti.

The concept of a "rate of return" (as used by Solow) goes back to Irving Fisher. But Pasinetti maintains that two different interpretations can be given of the concept as proposed by Fisher.

- (1) That rate at which two alternative investment options are equally profitable. This is a "supposed" rate of return which makes their present values equal.
- (2) A 'rate of return over cost' is the ratio of the 'permanent increase' in the income stream to a one time 'cost' or sacrifice of going from the present position (income level) to a higher (income) position. E.g., a farmer may be able to produce X_a amount of corn per year for ever. By sacrificing $X_a - \bar{X}$ this

year he can be in a position to produce X_b amount per year. The ratio R is then $\frac{X_b - X_a}{X_a - \bar{X}}$ in physical

terms, given that prices are constant. The investment is or is not profitable according to whether the ratio is greater or smaller than the current interest rate.

The two notions should be kept distinct from each other.

But a further step was taken by Fisher - successive investments of equal monetary value raise the permanent income stream by successively falling increments - the law of decreasing returns to additional sacrifice. Thus "where options are indefinite in number, the option chosen, compared with a neighbouring option with which it was in competition, yields a rate of return on sacrifice equal to the rate of interest. This rate was called the "marginal rate of return on sacrifice" - which became another term for "marginal product of capital".

Fisher was (according to Pasinetti) convinced that this represented something more (than the rate of profit) for the economy as a whole - it was not only independent but actually a determinant of the rate of profit.

Thus the argument was linked to the traditional demand and supply determination of the rate of profit (interest) in the economy, supply being determined by the time preference of

lenders, demand by the marginal productivity of capital.

But though aimed at drawing conclusions for the economy as a whole, the argument was always cast in terms of a single entrepreneur for whom the prices and the rate of profit had to be taken as given.

4.3.2 The argument can be studied in matrix formulation. The economy has two techniques of production, with a given and constant labour force. In the case where the w-r curves intersect at least once there would be a point where both could coexist at common rates of profits and wages.

An equal rate of profit for both implies that their two streams of future profits, set against the values of their capital goods satisfy the first of Fisher's concepts of the rate of return. (But of course with re-switching there may not be a unique w-r combination and relative price vector which satisfies the first concept). The switch point rate may be expressed as

$$r = \frac{pY_a}{pK_a} = \frac{pY_b}{pK_b} = \frac{p(Y_b - Y_a)}{p(K_b - K_a)}$$

where Y is the vector of outputs.

K is the vector of capital inputs.

p is the common relative price vector,

a, b, denotes the two techniques. But this is only a matter of defining the rate of profits; it is of no help in

explaining the level of rate of profits.

4.3.3 Now we may consider the other concept of the rate of return over cost. A change over from system a to system b is considered. The labour force is given and constant. The physical difference in outputs are $(Y_b - Y_a)$. The physical differences of (capital) inputs are $(K_b - K_a)$. The latter will in general have both positive and negative quantities. But the techniques may be such that in the transition some goods may become redundant. Suppose $K_a^{(w)}$ represents the vector of redundant goods, then out of the former stock K , only $(K_a - K_a^{(w)})$ are usable in the b system also.

Suppose that Y_a and Y_b contain exactly the same quantities except for the first commodity for which a larger quantity appears in Y_b than in Y_a .

Thus as a result of the change over the permanent increase in consumption (physically) is $Y_b - Y_a$, while the once and for all physical cost is $(K_b - (K_a - K_a^{(w)}))$. But cost and gain items represent heterogenous commodities. To aggregate them we require a system of prices. This depends upon the distribution of the net product between w and r which is as yet undetermined.

Thus Fisher's notion of rate of return over cost is not independent of the overall rate of profit.

Even if the latter were given arbitrarily, we would still have to choose between p_a and p_b price vectors, which

will, in general, be different.

The rate of return over cost then have to be expressed in terms of one of the price vectors chosen by convention - say p_a

The ratio then becomes :

$$\frac{p_a(r) (Y_b - Y_a)}{p_a(r) (K_b - K_a + K_a^{(w)})} =$$

If $K_a^{(w)}$ were a null vector there would be particular values of r where this coincides with the ratio defined earlier. But the latter is a much more general representation of the earlier accounting concept - in the sense that the latter always exists while the former may not.

The latter expression can be of some use only if the rate of interest is given. In that case, comparison of the ratio with r provides a rational criterion for the choice of technique and nothing more. Yet many economists have tried to view it (Fisher like) as the technical foundation of a theory of the rate of interest itself.

4.3.4 This claim is the result of trying to telescope a special and abstract case into something more general. The special case is the one where $(Y_b - Y_a)$ and $(K_b - K_a)$ consist of all zero components except the first one in each - call it the 'corn' commodity. Thus a change over from a to b system entails taking some corn from output and dumping it as a

means of production. All other things remain as they are. In this case the prices become irrelevant and the ratio can be expressed in physical terms.
$$\mathcal{R} = \frac{y_b - y_a}{y_a - \bar{y}} \quad \text{ratio of two}$$
 quantities of corn. (\mathcal{R} is the rate of return over cost of the change over from a to b). This ratio is independent of prices or the profit rate. Thus the choice of technique can be made according to whether the existing technique has $r < \mathcal{R}$ or $r > \mathcal{R}$. The changeover to a technique involving a higher (lower) capital per worker being advisable if $r < \mathcal{R}$ ($r > \mathcal{R}$).

If $r = \mathcal{R}$ the two techniques are equiprofitable.

The difference $r - \mathcal{R}$ is assumed to be an increasing monotonic function of r . - i.e. there can be only one value of r where $r = \mathcal{R}$ - there can be only one switch point.

This case may be extended to one where an infinite number of techniques exist. Then (according to Pasinetti) the switch points between techniques become irrelevant. At any rate of profit at which two techniques are equally profitable there always exists a third which is more profitable. In the limit there is always one most profitable technique at any single point in the range of variation of r . In the limit the ratio becomes a derivative, - what capital theorists call the marginal product of corn used as a capital good.

Thus though formulated in terms of vectors and matrices, this boils down to the familiar one commodity world. Here the rate of return on investment would, for technological reasons, be positive if the amount of corn were limited, so that an increase in its stock yielded a permanent increase in the level of net output. Given the law of diminishing marginal returns the rate of return could become an index of scarcity of 'corn capital'.

This is an abstract case. Such abstraction is always resorted to if it is of use in presenting a simpler and easily understood picture of the general case. This was also the purpose for which the corn (jelly, meccano) model was believed to be useful. The belief involved what Pasinetti chooses to call the unobtrusive portulate :-

(1) At any time that, at a wage rate w^* , two techniques are equally profitable, the technique that becomes more profitable at $w > w^*$ (or $r < r^*$) is the one which entails a higher value of capital per man.

This is supplemented by two further assumptions :

(a) It is always possible, for the economic system as a whole to change over from any technique to another without any loss of capital goods in the transition ($K_a^{(w)} = 0$) (the "malleability" assumption).

- (b) There exist a very high number of techniques, all of which may be ordered according to the proposition (1).

In that case the ratio reduces to :

$$TR(r) = \frac{p(r) (Y_b - Y_a)}{p(r) (K_b - K_a)}$$

Here prices are relevant. But given the unobtrusive postulate, $TR < r$ for any set of prices where $r > r^*$ (r^* = the switch point rate of profit between a and b techniques) and $TR > r$ for any prices where $r < r^*$. $TR = r$ for prices, where $r = r^*$. Thus when $r = r^*$, TR also corresponds to the first of Fisher's rates of return.

Thus though it is not a physical rate of return, the unobtrusive postulate has conferred upon it the properties of such a ratio - call it a 'surrogate' rate of return.

The discussion on re-switching has disproved the validity of the above construction - especially that of the unobtrusive postulate. The idea that lower rates of profit are a natural consequence of further additions to capital is revealed to be false. (See Chapter III, pp. 49-55).

The assumption of infinite number of techniques was made to enable a presentation of the argument in terms of infinitesimal increments of capital and to validate the concept of marginal productivity of aggregate capital. Now, however, neighbouring techniques on a "pseudo-production function" may well have large difference in the amounts (values) of

capital per man. Continuity in the variation of techniques does not imply continuity and monotonicity in the variation of capital value per man and net output per man with the rate of profit. Capital theory is rendered unsuitable for the application of calculus and marginal analysis. as far as the concept of aggregate capital is concerned.

Now the function $r - \mathcal{R}(r)$ is also not a monotonic increasing function of r ; the ratio \mathcal{R} is left bereft of the properties of the physical rate of return of the one commodity model.

The ratio \mathcal{R} in its most general form is

$$\mathcal{R} = \frac{P(r) (Y_b - Y_a)}{P(r) (K_b - K_a + K_a^{(w)})}$$

of course retains the nature of a 'rate of return' in an investment project designed to make a change over from a to b technique. (the price vector has to be chosen by convention). But that is all. It cannot, as the marginal productivity theorists intended, be built up as one of the pillars (the demand side) of a theory of the rate of profit. Fishers second notion, of the rate of return, as the first, is no help in this regard.

4.4.1 Solow's reply to Pasinetti (reading 50) was that there is no insistence on aggregation of the capital inputs into a scalar magnitude. Solow says he does not hold the peculiar version of the marginal productivity theory which

insists on such aggregation of capital inputs. He had never adopted the unobtrusive postulate. The proposition he had forwarded was as follows :

Given constant returns to scale and two techniques which are equiprofitable at a given real wage rate, let the economy exist at a steady state using one of the techniques. Then let it move over finite or infinite time to a steady state using the other technique. This generates series of consumption differences over time between the consumption stream that would have been possible without the transition, and one that is now possible. If there is an interest rate that discounts the stream of differences to zero, call it the rate of return. Then under certain assumptions the rate of return associated with the transition is equal to the switching rate for those techniques.

If only one consumption good exists the rate is a physical concept - showing the terms of trade of the intertemporal transformation of consumption. With many consumption goods prices are required to generate a stream of scalar difference magnitudes. For this, the intrinsic price structure common to the two techniques at the switch point can be used. It has nothing to do with multiplicity of capital goods.

"Pasinetti has missed the point if he thinks that 'giving up' of consumption goods is merely metaphorical". The 'giving up' consists of a diversion of resources from

the production of consumption goods to that of producer goods. This is the only way in which a society without idle resources sacrifices present consumption for future consumption." (Solow reading 50)

He (Solow) assumes that no capital goods have to be discarded in the transition. Otherwise the "rate of return" will not coincide with the switching rate of interest, a more general concept than 'the' rate of return will be required.

When we consider a continuous spectrum of techniques, the case can also be made to interpret every point a switching point. As the number of techniques increases, the number of switch points get larger. It seems more natural to say that the number of switch points becomes infinite than to say that it suddenly becomes zero.

Then if technique a dominates at r_1 , b at r_2 ($< r_1$) then all one can infer about the rate of return (r) between a transition from a to b is that $r_2 \leq r \leq r_1$. The range of indeterminacy shrinks as the number of techniques grows and the range of rates of profit at which any given technique dominates becomes smaller.

"No one is trying to slip over on him (Pasinetti) a theory according to which the rate of profit is higher or lower according to whether the existing quantity of capital is lower or higher and, as such, represents a general technical property of the existing quantity of capital". (Reading 50)

4.4.2 Pasinetti had made a clear distinction between the assumption and the unobtrusive postulate. The former were merely convenient whereas the latter absolutely essential for the marginal productivity theory of capital. He quotes Solow's remark that "one of the elegant show pieces of economics is its analysis of the resource allocation implications of the price system". In a general equilibrium framework, efficient prices emerges as having a meaning of indexes of scarcity for the corresponding scarce resources. Allocation is optimum because each resource comes to be used according to its relative scarcity.

It was the postulate which enabled capital theory to be absorbed into the same general equilibrium framework - making capital appear like a scarce resource and the rate of profit like any other general equilibrium price - an index of scarcity. This construction has now fallen.

Solow defence using Fishers notions of the rate of return is not admissible because these reduce to mere definitions when deprived of the marginal productivity framework through the use of the postulate.

A transition from a to b technique involves not just a difference in the 'consumption' good, hut also a difference in the whole structure of capital goods. There is then no unambiguous way of defining 'gains' and 'sacrifices' in the transition for this requires a system of prices. Using the

prices of a switch point is not an answer since these prices presuppose precisely the rate of profit which he wants to explain. The equality between his "rate of return" () and the rate of profit is only an accounting expression.

Pasinetti uses one of Solow's own examples to clarify the issue. There is only one technique but two economies using it, each producing a different bundle of final output. The price system is indeterminate: any arbitrary rate of profit can close it. In this case, it is just not possible to change over from one to the other by changing just one "consumption good". To produce more of one entails producing less of another. No physical rate of return exists. Yet, given any value of r^* Fisher's first notion of the rate of return exists and will indeed always be equal to r^* .

$$\frac{p^* (Y_b - Y_a)}{p^* (K_b - K_a)} = r^*$$

This is an identity; it cannot 'explain' the rate of profit; it is the rate of profit.

"This has nothing to do with the unobtrusive postulates of the marginal productivity theory of capital: it has nothing to do with any theory. If we have found the marginal productivity theory of the rate of profits as incorrect it is of no use trying to replace it with mere definitions - as the one above." (Pasinetti reading 34)

N O T E S

NOTE I

Marxist writers criticised this plea as follows: They maintained that since subjective preferences (utility and disutility of consumption and work-effort respectively) cannot be viewed as independent of the individual's initial endowment position (and hence of his class allegiance), this involves historical and institutional determination. Whether or not an individual possesses a transcendental scale of preferences can only be a matter for speculation, but intensity of desire for something and willingness to undergo pain of effort is definitely influenced by his 'initial' economic station (whether he is a 'have' or a 'have not'). Thus the plea for laissez faire on grounds of such a theory reduces to a plea for maintaining the current inequalities of wealth and income.

NOTE II

Marxists claim that marginal productivity attribute given to 'capital' is still no justification for a class of capitalists getting profit exclusively by virtue of their ownership of capital. To link the individual owner of capital with the profit income he received, the concept of 'abstinence'

proved to be very handy. But Marx has criticised this also as being an apologetic argumentation. (Dobbins, Hunt and Schwartz)

NOTE III

Here it may be asked why the same question cannot be posed with regard to labour, since this may be of different qualities. This is answered later in the main exposition.

NOTE IV

This device was used basically to counter Harrods problem of knife-edge stability requirements for economic equilibrium. But one need not enter into those issues to deal with the problem of capital in this kind of a model.

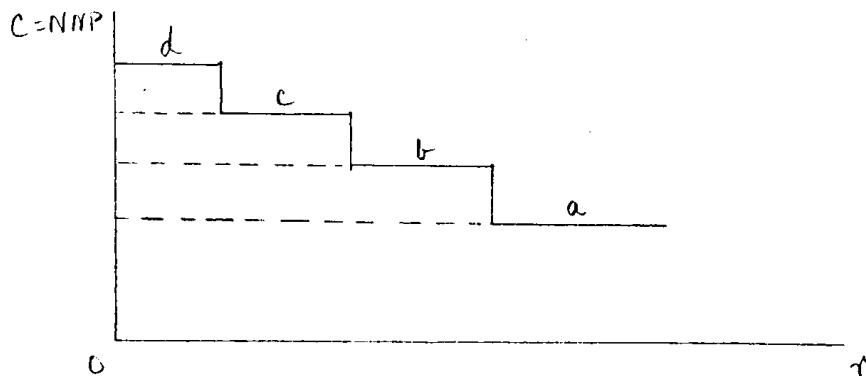
NOTE V

While r is a rate and has a base in the value of capital (at given r and w), w in the Sraffa system is a share of the 'surplus' going to labour. Now g is also a rate and also has value of capital as its base, c is also defined as a share of the surplus going for consumption. Nothing is implied about whether the resources for c (and g) come from w alone, or r alone, or both; they may come from either or both of these. The symmetry lies only in the nature of the

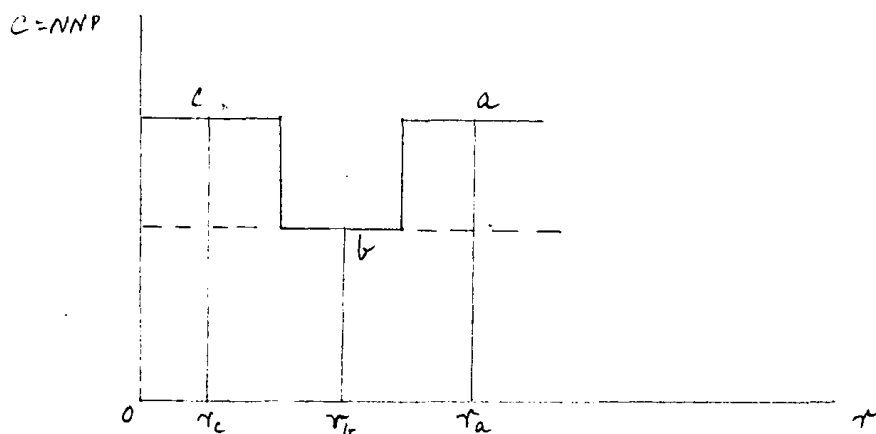
two trade-offs (between w and r on the one hand and between c and g on the other).

In a capitalist system the choice of technique is determined once the value of w is fixed. How that is fixed is not presumed to be known in the discussion so far. Given the value of w the technique chosen will be such that r is maximised (one can view it from the other side: if the value of r is given the technique chosen will be such as to maximise w ; entrepreneurs bidding for labour in the market will ensure such a choice of technique in order to be able to pay the highest wage to attract labour.), Given either r or w the technique chosen fixes the $c - q$ trade off. Given g (how and at what level is not presumed to be known) one can determine the share going for consumption (= consumption per capita because in our system total labour is equal to unity).

The surrogate model (as well as the Austrian capital model enabled the establishment of a monotonic relationship between r and c across stationary states (with zero growth rate). This can be depicted as follows :



But now with reswitching we have the following case :



Here when r drops from r_a to r_b , consumption per head actually falls. It rises as r drops further, But the level of consumption at $r = 0$ is also possible at higher values of r (e.g. r_a). One can no longer say that society moves from higher interest rates to lower ones by sacrificing correct consumption goods in return for more consumption later, and that each further dose of accumulation of capital results in a lower and lower social yield of incremental product. Thus against the orthodox model where we had concepts of capital deepening and diminishing returns to sacrifice of consumption now for consumption later, we now have what may be called reverse capital deepening and a denial of diminishing returns. (See Samuelson in symposium: Reading 43).

NOTE VI

Levhari attempted to show that reswitching is not possible in the case of a matrix as a whole. Four different

papers were devoted to refute Levhari's arguments in the symposium on capital theory in Q.J.E. 1966. The simplest of these is Pasinetti's where he slightly modified Sraffa's example and cast the argument in terms of a reducible matrix. Moreover Levhari's example (which pertained to irreducible matrices) was proved to be false even for irreducible matrices by counter examples by Morishima, Sheshinski and Garegnani. Even Pasinetti's example can be modified into an irreducible matrix and the plausibility of reswitching proved.

NOTE VII

This development did not take place after the fact that aggregate capital cannot be measured independently of distribution between labour and capital was firmly established by Sraffa. Solows position had taken shape even before the arrival of Sraffa's book; it seems to have been a reaction to Joan Robinson's attack on the concept of the aggregate production function in 1953. (Reading 37)

NOTE VIII

For example if, as against the current plan, the alternative plan involved giving up some consumption in the earlier and in the remote future years in exchange for

increased consumption in the middle years. The stream of net changes in this intertemporal exchange may not be summarised in a single "internal rate of return" (This is that rate of interest which would make the net present value of a stream of future costs and benefits equal to zero). If we represent our stream as follows

$$-k_0, -k_1, -k_2, +k_3, +k_4, -k_5, -k_6 \quad \text{where } n = 6.$$

The internal rate of return would be that value of r where

$$\begin{aligned} \text{NPV} = k_0 + \frac{-k_1}{1+r} + \frac{-k_2}{(1+r)^2} + \frac{k_3}{(1+r)^3} + \frac{k_4}{(1+r)^4} + \frac{-k_5}{(1+r)^5} \\ + \frac{-k_6}{(1+r)^6} = 0 \end{aligned}$$

But this is a polynomial of the 6th degree and it would have six roots. If two or more of these roots are positive (negative roots are ignored) we would have more than one internal rate of return for the same stream of intertemporal changes in the plan.

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This is not all there is to the debates between the neoclassical, and neoKeynerian and neo-Ricardian contestants. At least four new books have come to my notice containing articles which carry the debate forward. However, this happened at a stage when I was close to completing the survey of the debates as presented in this dissertation; lack of time prevents my including the latest developments in the survey.

These books are as follows :

- (1) Essays in Modern Capital Theory, Brown/Sato/Zarembka (editors).
- (2) Samuelson and Neoclassical Economics, ed. by G.R. Feiwel.
- (3) The crisis in economic theory, edited by Daniel Bell and Irving Krietsl.

All these books were acquired by the Servants of India Society Library (the only library to which I had access) after the first week of August 1982.