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THE ORGANIC COMPOSITION OF CAPITAL

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The concept of 'the organic composition of capital' is an important element in Marxian analysis; because of its connection with a theory of a falling rate of profit, it has been taken to resemble the neoclassical concept of 'the ratio of capital to labour' and since the latter has been pulverised by SRAFFA's critique[1] it is necessary to re-examine the former in the same light.

I

The notation in which MARX set out his formal analysis is very confusing. A flow of production, say per week or per year, in terms of *value* is expressed as $c + v + s$, that is, the *values* of the depletion in the pre-existing stock of means of production, of wages and of surplus. Net output, $v + s$, represents all the man-hours of work performed over the period. (The labour-force is partly engaged on replacing means of production, but this is compensated for by c, the *value* released from the means of production used up.)

At the same time, Marx writes $c + v$ for the stock of capital and c/v for organic composition. Clearly the stock of constant capital is a multiple of c, the depletion of the stock, say *per annum*, that has to be made good over the period. Let us write C for the stock of physical means of production in existence at a moment of time. But then what is v, regarded as part of the stock of capital? At one time I believed that 'variable capital' should be treated as a wage fund, represented

* Cambridge, Great Britain.

1. *Production of Commodities by Means of Commodities,* Cambridge University Press, 1960.

by V, so that the stock of capital should be written as $C + V$. But now I think that this was a mistake. A wage fund is essentially a financial concept – the sums required to pay out wages over the period of turnover of working capital.

In RICARDO's corn model, the turnover period was given by nature – the period from harvest to harvest, which is a year in high latitudes, and the wage fund had a physical existence as a stock of grain, available after the harvest to be paid out week by week until the next harvest. In tropical agriculture and in manufacturing industry, the turnover period of working capital may be much shorter than a year or sometimes longer, and it varies for various lines of production and for various techniques; there is no standard turnover period to define the wage fund required for output as a whole. Furthermore, the equipment and stocks required for producing a flow of output of wage goods cannot be distinguished (like corn in a barn) from the rest of the stock of means of production. Thus it seems best to write C for all existing physical capital, including stocks of grain, and to use v only in one sense – the flow of *value* of wage goods being produced.

It is clear that MARX thought of the stock of capital as consisting of two parts; one part was the physical means of production and the other part somehow represented labour employed, organic composition being the ratio between them, but there does not seem to be any way of representing this in his notation as c/v.

An alternative definition of organic composition is 'the ratio of dead to living labour', that is the quantity of labour embodied in the stock of means of production, required for a particular technique, per man employed on current production. Here, as we shall see, we can find a clue to guide us through the mazes of 'capital theory', but it has to be handled with care.

II

A change in methods of production brought about by accumulation and technical improvements is an extremely complex process. It is best to begin by comparing 'islands' each using a different technique, each equipped with the stock of means of production that its technique requires. Since the comparison is a pure intellectual experi-

ment with no pretension to realism we can simplify it as much as we like provided that we introduce no inconsistencies into the picture.

The concept of the *technique* for producing the whole output on an island is basically the same as SRAFFA's 'system' of equations depicting all the physical relations between the ingredients in a flow of production and the labour force that operates them. However, we modify the details of SRAFFA's picture to suit the requirements of our problem.

SRAFFA's system was designed to emphasise the effects of differences in the rate of profit in a single economy, while we are interested in differences between economies that are independent of differences in their rates of profit.

Instead of SRAFFA's distinction between basics and non-basics, we depict a physical difference between net (consumable) output and means of production. Net output is measured in 'baskets' made up of commodities in fixed proportions, the same on each island. The labour force on each island consists of the same number of men, working the same hours per day, per week and per year. Each labour force produces a flow of output of baskets while keeping intact the stock of means of production required for the technique that it is operating.

We can compare flows of production growing through time provided that the growth rate is the same on each island, but the most convenient growth rate to take is zero. On each island the whole net output is consumed and the stock of means of production is continually being replaced, item by item. We need not bother about the distinction between equipment, say 'machines', and stocks of materials being used up in the process of production, for the whole stock on each island has existed in its present form from time immemorial; a photograph of it taken on a given day in any year would always look exactly the same. Consumption of workers and of rentiers is of baskets of uniform content so that the distribution of income does not influence the composition of net output.

Now we come to the difficult question. How are we to compare the stocks on different islands, each being composed of the entirely different physical items required for different techniques?

MARX was content to treat the stocks as 'dead labour', that is, he

measured a stock by the number of man-hours of work performed in the past to produce it, but this is very rough, for a stock of means of production was not produced by labour alone. The flow of net output *per annum* can be represented by its *value*, $v + s$, a number of man-hours of work, but to produce a physical output workers require a pre-existing stock, appropriate to the technique in use, of which a part, c, is used up and replaced during the year. MARX treats c as a quantity of *value*, formerly created and now released, but this year's c could not have been produced without the aid of some earlier pre-existing c.

This conception plays an important part in SRAFFA's argument. It means that the cost of investment cannot be reckoned in terms of labour alone. It depends also on the time-pattern in which the work was done and this entails that the value, in any *numéraire*, of a specific physical stock of available inputs varies with the rate of profit.

We cannot get out of this difficulty merely by postulating that the same rate of profit is actually ruling on each island. We do not have any theory of what determines the ruling rate of profit on any island, only, following SRAFFA, an acount of the relationship, for any specified technique, between the rate of profit and the share of wages in net output. But we can escape the difficulty, for the purpose of an intellectual experiment, by postulating that the time pattern is the same for all techniques.

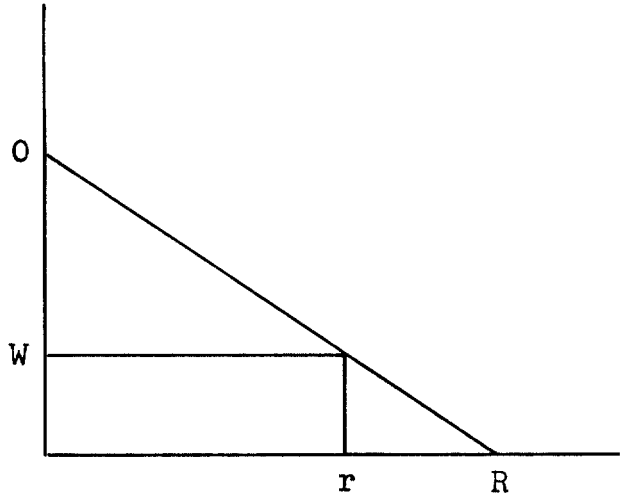
Divide the labour force into two sectors. In one sector, workers are operating 'machines' to produce a flow of 'baskets'. Here the period of throughput is very short, so that work in progress as part of the stock can be neglected. In the other sector, workers (with the aid of machines) are replacing machines as they wear out. Now suppose that, on each island, the stock, whatever it may be is completely replaced every ten years. Then C, the stock measured in labour-time, is ten times c, the annual depletion of stock. An island where C is larger has to have a greater proportion of the labour force in the machine-making sector and requires, in a clear sense, a higher capital to labour ratio to operate its technique. By this, or some equivalent set of assumptions, we can justify treating differences in stocks as differences in 'labour embodied' and we can write organic composition as C/L where L is the number of men employed.

In this part of MARX's argument the problem of effective demand

(realisation of the surplus) does not arise, so that we assume given employment (not necessarily full employment) on each island.

We can now present a technique in a modified version of SRAFFA's wage-profit diagram. SRAFFA's curves, though with a consistent negative slope, are full of wiggles. This was very important in the capital controversy but in the present context we are not interested in re-switching and all that. We will suppose that on any island, labour-value prices rule, that is to say that the relative prices of items in the basket and in the stock of that island are the same (at any rate of profit) as they would be at a zero rate of profit. Then on each island the wage-profit curve is a straight line. (This is in no way necessary to the logic of the argument; it is introduced merely to simplify exposition.)

Figure I

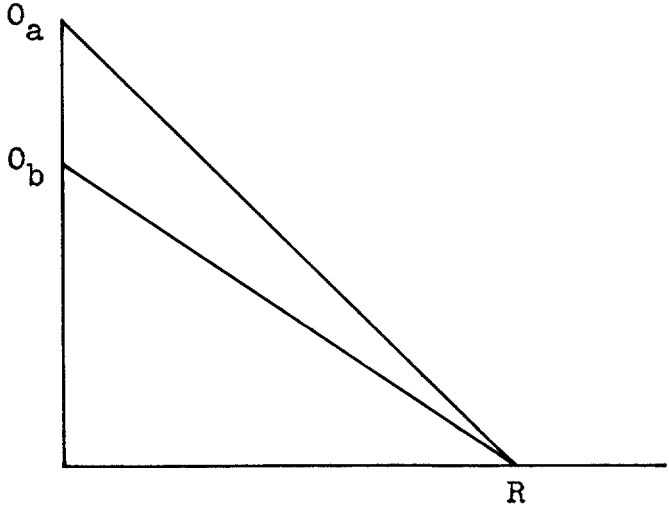


A given labour force, L, is providing a flow of work ($v + s$ per man) which produces a flow of net output, O/L, while keeping intact the physical stock of means of production represented by C. Net output, in 'baskets', is shown on the vertical axis and the rate of profit on the horizontal axis. The maximum rate of profit, corresponding to the imaginary position of zero wages, is shown by R. K, the

value of capital, in terms of a unit of output is O/R. (With labour *value* prices for all items of current output, the value of capital is independent of the actual rate of profit.) The capital to labour ratio, K/L, is shown by the slope of the wage-profit curve, OR, and the output to capital ratio, O/K, is shown by R, the maximum rate of profit. Thus, a higher capital to output ratio is shown by a steeper slope and a lower capital to output ratio by a higher maximum rate of profit. In the diagram, the actual rate of profit is shown as r and the wage as W. The rate of exploitation (s/v) is shown as $O–W/W$.

We are interested in comparing five typical islands. *Beta* is the basis for comparison; on three superior *Alpha* islands, output, O/L, is greater than on *Beta* without requiring a higher capital to output ratio, K/O. There is also an intermediate case, quasi-*Alpha*, on which O/L is greater than on *Beta* but in a smaller proportion than K/L, so that K/O is greater.

Figure II

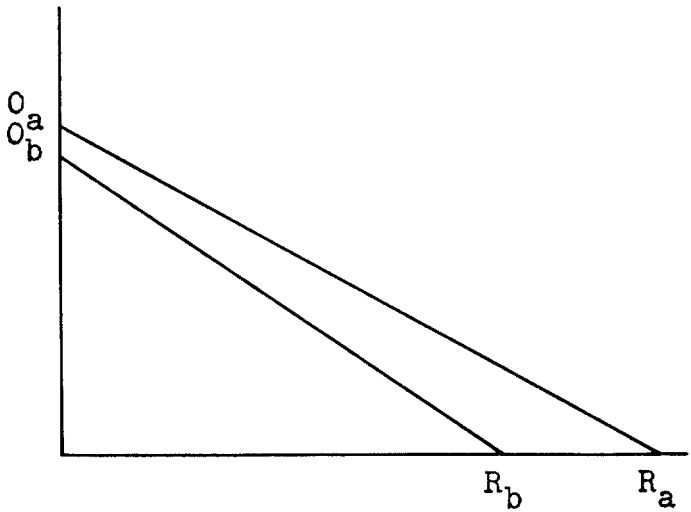


On *Alpha I*, net output for the given labour force is greater than on *Beta* while the maximum rate of profit R, is the same. The value of capital, K, is greater on *Alpha I* than on *Beta* in the same proportion as output is greater; thus $O_a/K_a = O_b/K_b$.

The relation of these two techniques to each other is neutral.

On *Alpha II* the technique in operation is capital-saving in comparison with *Beta*. Machines in the investment sector which are used to produce machines are of superior design such that a smaller proportion of the labour force is required to keep the stock intact. For this reason, net output (for the labour force as a whole) is higher on *Alpha II* than on *Beta*, even if physical output per man in the consumption sector is identical. Here K_a/O_a is less than K_b/O_b.

Figure III



MARX regarded capital using change – a rise in organic composition -- as the normal case. This is illustrated by the comparison of *Alpha III* with *Beta*.

The capital to output ratio on *Alpha III* is lower than for *Beta*, although the cost of investment per man employed is greater. $K_a/L > K_b/L$; $K_a/O_a < K_b/O_b$. This appears to correspond to the type of technical development most prevalent in modern large-scale industry.

In all three cases, if we compare the techniques at a given real-wage rate, *Alpha* yields a higher rate of profit than *Beta*.

Figure IV

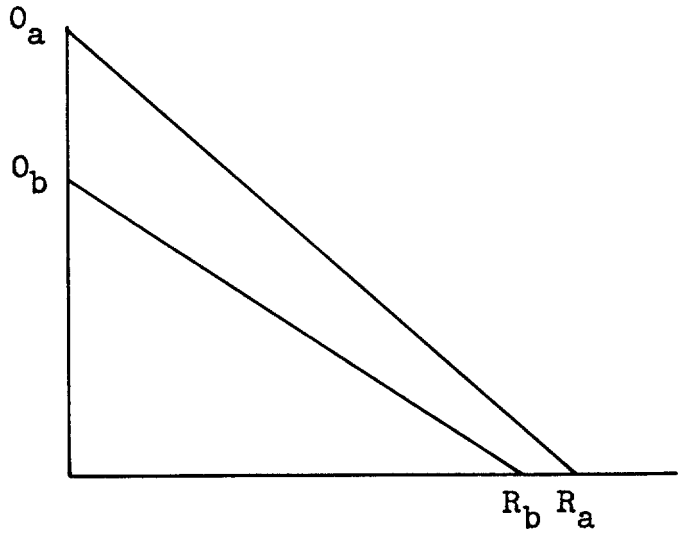
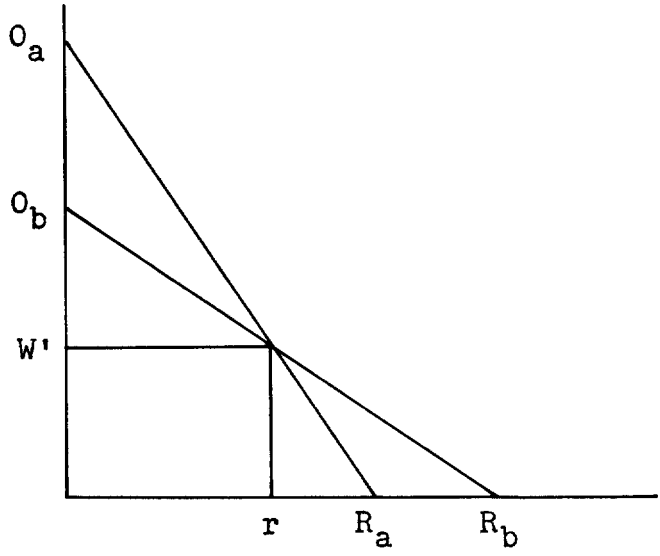


Figure V



The intermediate case, quasi-*Alpha*, is shown in *Figure V*. Here higher net output per man, O/L, requires a cost in terms of labour embodied in the stock of capital per man employed higher in a greater proportion. Thus the capital to output ratio in this case is greater than for *Beta*. $K_a/O_a > K_b/O_b$. The maximum rate of profit, R_a, is lower than R_b.

Here there are two ranges of cases. On an island where the wage rate was below the level corresponding to the intersection of the curves (W' in the diagram) if the *Beta* technique was known, the quasi-*Alpha* technique would not have been installed, but at any higher level of wages, quasi-*Alpha* offers the greater rate of profit.

Over that range, $O_a - W'$ is greater than $O_b - W'$ in a greater proportion than K_a/L is greater than K_b/L. Similarly, if the rate of profit is less than r, quasi-*Alpha* provides the higher wages.

MARX wanted to argue that rising organic composition would cause the rate of profit to fall (though when he was working on Volume III of *Capital* he was evidently very uneasy about this proposition[2]). The above analysis indicates a missing link in his argument which he evidently overlooked.

III

In a recent contribution to the debate[3], Professor OKISHIO purports to provide the assumptions which would justify MARX's proposition, but he falls into a trap of Marxian terminology. He treats $v + s$ (labour time) as the measure of product and so identifies the capital to output ratio with the capital to labour ratio. A rise in organic composition, by definition, is a rise in the capital to labour ratio. It lowers or raises the capital to output ratio according to the technique which it embodies. Furthermore, a rise in the capital to output ratio does not cause the rate of profit to fall, for a capital-using technique would not be adopted unless it raised profit per man employed at least as much as the cost of investment per man.

OKISHIO goes on to construct a diagram of the same type as those

2. *Capital*, Vol. III, chapter 14.

3. N. OKISHIO, «Notes on technical progress and capitalist society», *Cambridge Economic Journal* (1977), March.

used above, with output in terms of wage goods on one axis and the rate of profit on the other. He emphasises the character of a superior technique (*Alpha* compared to *Beta*) but he maintains that MARX's theorem would be correct if technical progress was confined to the type, quasi-*Alpha*, which requires an increase in the capital to output ratio. He noticed, in the diagram, that the quasi-*Alpha* technique has a lower maximum rate of profit than *Beta* but he failed to notice that at any wage above W' (at the level of the intersection of the curves) the rate of profit is higher for quasi-*Alpha* than for *Beta*.

The ratio of the quasi-*Alpha* to the *Beta* wage, at a common rate of profit, is less than the ratio of the outputs. To yield the same profit with a greater K/O the share of profit in the *value* of output (s/v) must be greater. Thus MARX was correct in saying that, if the rate of exploitation (in terms of *value*) was unchanged, a rise in organic composition would lower the rate of profit. But here we are not concerned with *value* but with physical output. In a comparison of quasi-*Alpha* with *Beta*, when the rate of profit is the same, the real-wage rate in terms of output is higher.

There is another inconsistency in Professor OKISHIO's analysis, besides identifying organic composition with the capital to output ratio. He writes L for the flow of *value* being produced without distinguishing between the number of men and the hours of work that each performs. In order to keep in touch with this argument, we assumed above that hours of work were the same on all islands, so that both L, the number of men employed, and $v+s$ were the same everywhere but it would be much more natural to suppose that hours of work are less on the islands where output per man is greater.

MARX argued that normally a capitalist employer must maintain a rate of real wages sufficient to support life (the *value* of labour power) while the more effort per day he can squeeze out of the workers and their families, the greater the surplus *value* that he extracts. This applies to a one-technique, one-shift system. It is painfully true of situations where unorganised, under-employed workers are being absorbed into a capitalist labour force. But where a strong trade-union movement has been able to claim a share in the fruits of advanced technology, the advantage has been taken partly in reducing the working day and increasing holidays.

Where the technique in use requires heavy investment, multiple shifts make the working day of equipment twice or three times that of the average wage-earner. This has to be taken into account in measuring the capital to labour ratio. It cannot well be represented by lumping L and $v + s$ together.

IV

The discussion of the Marxian theory of a falling rate of profit has been heavily impregnated with ideas drawn from neoclassical doctrines, but meanwhile those ideas themselves have been discredited.

In pre-Keynesian theory, 'saving', that is accumulation of financial capital, forces down the rate of interest (identified with the rate of profit) and so induces the use of more capital-using techniques. This concept has not survived the abrogation of SAY's Law by KEYNES and KALECKI; the concept of 'the marginal productivity of capital' which falls as the 'capital' to labour ratio rises has not survived the 'Cambridge criticism' which draws a clear distinction between financial capital and a stock of man-made means of production.

The neo-neoclassics have shifted their ground and adopted the concept of a pseudo-production function[4]. This can be represented by a series of islands in which each requires a higher capital to output ratio than the last (as in the comparison of quasi-*Alpha* with *Beta*).

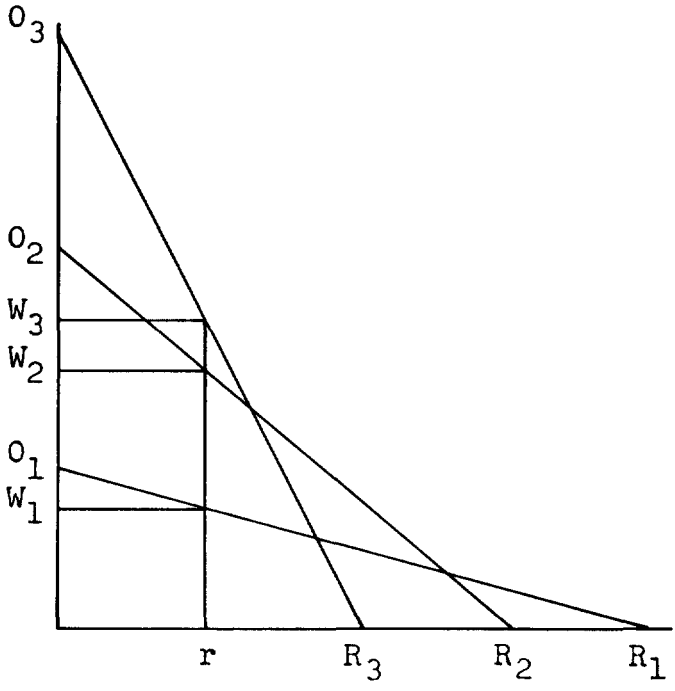
A technique with a higher capital to output ratio, K/O, has a lower maximum rate of profit and a smaller share of wages in net output, but since net output is higher, it is not necessary that the rate of profit should be lower.

We can run over the series of techniques assuming the same rate of profit to be ruling on each island (shown as r in the diagram).

With a common rate of profit, the ratio of the wage to output falls as we ascend the series. In the limit, the increment to output is only just sufficient to yield the constant rate of profit on the increment to the cost of investment, so that the wage rate remains unchanged.

4. See P. SAMUELSON (1962), «Parable and Realism in Capital Theory: The Surrogate Production Function», *Review of Economic Studies*, Vol. 29, pp. 193–206.

Figure VI



Beyond this point, no further 'deepening' of the stock of capital takes place.

This is a version of the neo-neoclassical theorem, that the maximum output obtainable by deepening the stock of capital (raising K/L) is that which requires zero consumption by capitalists.

The explanation is that, on an island where the stock of means of production is greater, the proportion of the labour force required to maintain it is higher. The limit is reached at the point where the increase in net output due to a more capital-using technique is no greater than the output lost by transferring the requisite amount of labour into the investment sector.

We may observe that the lower the rate of profit at which the comparison is made, the higher the maximum value of K/L. This would not necessarily be true if we had not eliminated reversals and reswitches from the pseudo-production function by assuming labour-

value prices to rule on each island. In fact this construction is exactly the same as Professor SAMUELSON's 'surrogate production function' which was devised to answer the Cambridge critics. Yet SAMUELSON seemed to believe that his construction was supporting the neo-classical doctrines of a falling marginal productivity of increments of capital applied to labour.

It seems to me to be a great insult to MARX to foist this conception upon him. It is far more honourable to him to admit that his *value* system is not all-inclusive than to try to make out that he was really a neoclassic at heart.

The limitation on the *value* system is precisely that it does *not* provide a unit of physical output. MARX listed among the counteracting causes that check the tendency for the rate of profit to fall, the fact that technical progress may reduce the cost in terms of labour-time of the physical ingredients in the stock of means of production, thus reducing C while leaving $s + v$ unchanged. (This is our case of *Alpha II*, but without taking account of the increase in O/L.)

He failed to notice the main counteracting cause. A superior technique does not necessarily require a rise in the capital to labour ratio (as MARX admitted) but when it does, it raises the output to capital ratio. Even a quasi-superior technique leaves room for a constant rate of profit with a rise in real wages, or a rise in the rate of profit with constant real wages.

There are many influences that may cause the overall rate of profit to fall as capitalism develops, but rising organic composition has not been shown to be one of them.

V

The foregoing argument is conducted in terms of comparisons of economies each adjusted to its own technique. MARX was actually interested in a historical process of accumulation and technical change going on through time.

This involves the whole of economic theory and most of economic history as well. Our model is too limited to contribute much to it. We have not discussed changes in the labour force and in the types of work required, nor the availability of natural resources, nor problems of the uneven development of national economies. The assump-

tion of rising consumption per head of identical 'baskets' of goods is unnatural, for technical change is largely devoted to changing the nature of commodities. We have not touched upon the manner in which innovations are made by profit-seeking firms or the process by which competition diffuses them. We have not discussed the finance of investment or the conception of technological obsolescence.

All the same, there are three very important generalisations towards which our argument can be seen to point.

First: if real wages do not rise when productivity is increasing, the rate of profit, in general, will not be maintained, for there will be insufficient expenditure to make a market for the greater flow of output (unless investment happens to increase or thriftiness to fall sufficiently to make up the deficit in effective demand). This is the paradox of capitalism. Every individual employer gains by reducing the cost of labour in terms of his own product but, taken together, they cannot prosper unless real-wage rates are rising.

Second: when accumulation has been going on for some time with more or less neutral progress on balance and then the latest eligible techniques take a capital-using form, there will be a gradual decline in employment offered at full-capacity operation of the stock of means of production, unless the flow of gross investment rises sufficiently to equip the labour force at the same rate as before with the new, more capital-using plant. This was RICARDO's argument about the introduction of machinery[5]. It is seen today in dramatic form in Third World countries which are being invaded by modern capitalism.

Third: when accumulation has been going on for some time with increasing employment and a moment comes when the reserve army of long-run unemployment is exhausted, a scarcity of labour develops in the sense that capitalists want to continue to increase output but cannot get any more hands. This situation is a strong stimulus to technical change, but there is no reason to expect the capital to labour ratio to be raised. On the contrary, in this situation, the motive is all in the direction of saving labour, that is, raising output per man, and this applies just as much, if not more, in the production of means of production as in the output of consumable commodities.

5. DAVID RICARDO, *Principles*, 3rd edition, Chapter 23.

These reflections show that when Marxian analysis is disentangled from its false association with the neoclassical production function, it is seen to be all the more cogent.

SUMMARY

The Marxian theory that rising 'organic composition' causes the rate of profit to fall has been wrongly interpreted in terms of a neoclassical production function. When techniques are compared in stationary states, organic composition can be represented by the ratio of labour embodied in the stock of means of production to labour currently employed. A superior technique increases output per man and reduces the capital to output ratio, even when it raises the capital to labour ratio. A quasi superior technique requires a rise in the capital to output ratio but not a fall in the rate of profit. Professor OKISHIO's attempt to rationalise MARX's theorem fails because he confuses the capital to output ratio with the capital labour ratio. When the Marxian theory of accumulation is rescued from these confusions it appears all the more important and relevant to modern problems.

ZUSAMMENFASSUNG

Die marxistische Theorie, die besagt, dass eine zunehmende organische Zusammensetzung des Kapitals ein Fallen der Profitrate nach sich zieht, ist bei einem Versuch, ins Konzept einer neoklassischen Produktionsfunktion übersetzt zu werden, missverstanden worden. Wenn mehrere Produktionsprozesse in einem stationären Zustand verglichen werden, kann die organische Zusammensetzung als das Verhältnis von im Produktionskapital verkörperter Arbeit zur Zahl der gegenwärtig beschäftigten Arbeiter ausgedrückt werden. Ein überlegener Produktionsprozess erhöht den Ausstoss pro Arbeiter und senkt das Verhältnis von Kapital zu Output, auch wenn die Relation Kapital zu Arbeit zunimmt. Ein quasi-superiorer Produktionsprozess ist zwangsläufig mit einer Erhöhung des Verhältnisses Kapital zu Arbeit verbunden, nicht aber mit einem Absinken der Profitrate. Professor OKISHIO scheitert bei seinem Versuch, MARXS Theorem zu erklären, weil er das Verhältnis Kapital zu Output mit dem Verhältnis Kapital zu Arbeit verwechselt. Wenn die marxistische Theorie der Akkumulation von diesen Verwirrungen befreit wird, erscheint sie um so wichtiger und relevanter zur Erklärung heutiger Probleme.

RÉSUMÉ

La théorie marxienne selon laquelle une 'composition organique' du capital croissante entraîne une baisse du taux de profit a été traduite à tort par une fonction de production néo-classique. Si l'on compare les techniques dans des états stationnaires, on peut représenter la composition organique par le rapport de la quantité

de travail incorporé dans le stock de moyens de production à la quantité de travail appliqué à ce stock. Un progrès technique augmente la production par tête et réduit le rapport capital/production, même quand il entraîne une augmentation du rapport capital/travail. Un pseudo progrès technique nécessite une augmentation du rapport capital/production, mais pas une baisse du taux de profit. Le professeur OKISHIO échoue dans sa tentative de rationalisation du théorème de MARX parce qu'il confond le rapport capital/production et le rapport capital/travail. Libérée de ses interprétations erronnées, la théorie marxienne apparaît parfaitement appropriée à l'appréhension des problèmes contemporains.