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SOLOW ON THE RATE OF RETURN

THE three lectures delivered by Professor Solow at the F. de Vries Foundation [1] are full of sharp observations and interesting asides. The main theme is the reinterpretation and defence of the concept of marginal productivity, which provides an occasion to try to advance towards a better understanding of the latter-day neo-classicals.

I

He opens boldly by asserting that everyone except Joan Robinson agrees about capital theory. However, there is one point on which I agree with him—that the notion of factor allocation in conditions of perfect competition makes sense in a normative theory for a planned economy rather than in a descriptive theory for a capitalist economy, and that the notion of the marginal productivity of investment makes sense in the context of socialist planning. I have tried to start students thinking along these lines.

For the planner who takes over at a particular moment in history there are in existence certain concrete means of production, and " a given state of knowledge " that includes all the techniques that have been in use anywhere in the world since 1760. The cost to society of a slightly greater amount of investment this year can be expressed in terms of the consumption that has to be foregone. For instance, if there is an excess of available labour over the employment offered by equipment for producing consumable commodities, which is the typical state of affairs in underdeveloped economies, the cost to society of labour employed in investment is zero. The benefit to society of a little more rather than a little less investment this year is derived from the additional means of production that it creates. Professor Solow measures this benefit by the amount of extra consumption that could take place next year without reducing future growth below the amount that would have been achieved if the extra investment had not taken place. This seems to be somewhat arbitrary. The purpose of investment is to increase productive capacity. Why work out what would happen if it were disinvested again next year? It would be very troublesome to make the calculation. The planner, who must be concerned with long-lived installations, has to think in terms of alternative paths to be followed over the next twenty years or so, and even a small change in the amount of investment decided upon this year may require extensive changes in the physical specifications of the plan over a long future as well as for this year. And so does the consumption to be permitted next year. However, Professor Solow admits that his is only one possible measure of the marginal productivity of investment from the point of view of

[1] *Capital Theory and the Rate of Return*. By R. M. Solow (Amsterdam: North Holland Publishing Company, 1963. Pp. 98. 21*s*.).

society, and I have argued that it can, in principle, be measured; if everyone else is of the same opinion, so much the better.

The difficulty is to connect this line of thought to the neo-classical theory of distribution. We may postulate that, in the planned economy, consumable income is distributed as wages, and that all production can be divided into outputs of consumable commodities and capital equipment (abstracting from armaments, social services, etc., and from investment in working capital). Then, labour in the two sectors being alike, the real wage bears the same proportion to the average output per man employed in producing commodities that employment in that sector bears to total employment. (When 20% of labour is otherwise employed the wage is 80% of the average output of a man in the commodity sector.) It has nothing whatever to do with the marginal product of labour. This is most sharply seen in the extreme cases, where the marginal product of labour in the commodity-sector is zero because all plant is already working to capacity, and where it is equal to average productivity, because there is idle plant of not less than average quality. (This might occur where the planner has taken over an economy which was formerly saving less than he now decrees.)

How can this be reconciled with the neo-classical micro-economic proposition that in conditions of perfect competition (abstracting from interest on working capital) the marginal product of labour equals the real wage? Logic is the same for everyone. There cannot be a special kind of neo-classical logic. When Professor Solow and I make the same assumptions we ought to come to the same conclusions, errors and omissions excepted.

Let us take his assumptions. All output consists of a homogenous physical substance, let us call it butter for short. There is a proper neo-classical production function with butter as output and labour and butter as input. With a given heap of butter in existence, there is a definite marginal product, at full employment of the labour available, being the output of butter lost when one man-year of labour is withdrawn. This is, evidently, independent of the consumption of butter. The wage, however, depends upon the proportion of the year's output of butter that is to be added to stock.

Now consider a capitalist economy with the same labour force, the same quantity of butter in existence and investment plans which will cause the same quantity of butter to be added to stock, as in the planned economy. First take a case where the level of investment is rather low, so that in the planned economy the wage-rate would exceed the marginal product of labour. If, in the capitalist economy, the wage was equal to the full-employment marginal product the wage bill in terms of butter and the amount of butter put to stock would not exhaust full-employment output. Full employment could be realised only if the capitalists consumed a sufficient amount of butter.

If workers save some of their wages consumption of unearned income has to be all the greater.

Perhaps it is helpful to introduce a money price of butter into the argument. The wage-rate is fixed in terms of money, and butter is sold for consumption. If the only purchasers are the wage-earners the total gross profit on the sale of butter for consumption cannot exceed the wage bill for the butter added to stock. With butter selling at this price the value of the marginal product of labour at full employment is less than the wage. Therefore employment must be sufficiently less than full to ensure that the higher physical product per man, together with the larger gross profit per unit of butter sold, raises the value of the marginal product to equality with the wage. Alternatively, capitalists may spend a sufficient proportion of their profits on consumption of butter to secure full employment.

When the rate of investment is so high that, in the planned economy, the wage would be less than the marginal product at full employment there would be excess demand for labour in the capitalist economy. In money terms the wage-rate would be bid up by employers eager to get hands until some action was taken to check the inflation. Either investment must be checked or there must be a levy on wage-earners to reduce consumption.

Given the propensities to consume of capitalists and workers, when the rate of investment is such as to secure full employment without excess demand for labour, the marginal product of labour at full employment is equal to the wage.

Once the real-wage rate is known, with given technical conditions we know the share of gross profits in the value of output. In the butter economy we can calculate the rate of profit on capital (after slipping in a proviso that the value of a stock of butter is independent of its age). But Professor Solow agrees with me about the difficulty of giving a meaning to the value of capital, and therefore to the rate of profit, outside the butter economy, in a short-period situation with an arbitrarily given stock of means of production.

The expected rate of profit on new investment (which may be supposed to influence decisions of capitalists) depends upon what they expect to happen to prices and wages in the future. If they project the present prices of various products (abandoning the butter consumption) they will see different rates of profit on different investments, and presumably each investor will go in for the lines within his sphere of competence that promise the highest rate. Over the long run there is a tendency, in Marshall's sense, for the rate of profit towards equality in different lines. But this arises because each individual capitalist wants to get the best return on his individual investment. There does not seem to be any reason for the planner to act so. He may have worked out the marginal productivity of investment in some sense, but he does not care about the expected rate of profit, while the capitalists are interested in the rate of profit and do not care about marginal productivity.

II

In the next lecture the scene changes. The economy gets into long-period equilibrium, with a constant rate of profit. This must mean that all pro-

ducts are selling at normal prices, in the sense that gross margins cover depreciation and profit at the ruling rate on the value of equipment involved in production. At any moment, with given technical conditions, the real-wage rate is then determined. Technical progress is going on and full employment is being preserved. To simplify, let us suppose that employment is constant. Output is then growing at the rate g, at which output per head is rising—the " natural " rate of growth in Harrod's sense.

Now that we are in equilibrium I do not see why we should not talk about the value of capital. When the share of net profit in the value of net output (reckoned in terms of commodities) and the rate of profit are both constant the value of capital is growing at the rate g. If K is the value of capital and I a year's net investment $I/K = g$. When all wages are consumed, $I = sP$, where P is net profit and s the proportion of net profits saved. Then P/K, the rate of profit, is equal to g/s.

These are merely accounting identities, but it is useful to keep them in mind.

For Professor Solow, however, " capital " is something physical. The discussion of technical progress is not easy to follow because, in spite of all his good resolutions, he frequently refers to the quantity of " capital " without saying what it is a quantity of.

In the case of purely disembodied progress, which affects old plants, not merely the blue-prints for new ones, presumably " capital " means a stock of equipment. When employment is constant and equipment is being kept intact, disembodied technical progress is raising the output of commodities at the rate g. Since the rate of profit is constant, the real-wage rate must be rising at g. Once more it simplifies matters to bring money wages into the argument. Let us postulate that the money price of commodities is constant. Then the money-wage rate is rising at g, the reproduction cost, and therefore the money value of the stock of physically unchanged equipment is rising at the same rate.

A kind of technical progress can be conceived in which physical equipment per unit of output remains constant, while output per man both in producing equipment and in producing commodities rises at a steady rate. (Cloth per loom remains constant, but the number of looms that a weaver can mind is rising at the rate g, and so is the number of looms produced per man employed in the investment sector.) This seems to be the picture that Professor Solow has in mind when he discusses embodied technical progress. He mentions, but does not elaborate, the case of truly embodied progress, where improvements are made in the design of equipment, which is therefore continuously changing in physical form. In golden-age conditions, with a constant rate of growth and a constant rate of profit on capital (which entails that real wages are rising at the rate g), all three kinds of technical progress come to much the same thing.

In Professor Solow's scheme there is also a production function. What

does this mean? Presumably we are invited to consider a number of economies, all being presented with the same series of technical possibilities as time goes by, each with a different rate of profit. An economy with a lower rate of profit has a higher real-wage rate at any moment of time, and, measuring equipment in units of productive capacity, a larger stock of equipment.

The locus of points corresponding to the positions of these various economies at any moment is not, strictly speaking, a production function. It is similar to Professor Samuelson's so-called " surrogate production function " and my " real-capital-ratio curve," which show the possible positions of stationary long-period equilibrium compatible with one " state of technical knowledge " in the sense of the book of blue-prints exhibiting the technology known at one moment in history. But there is a new book of blue-prints every year, the same for all the economies, and the locus of possible equilibrium points corresponding to each new book has the same shape all the time.

This seems to be an extremely implausible concept and quite unnecessary to the development of the analysis. Professor Solow has evidently introduced it out of piety to neo-classical traditions.

He tells us that his production function is Cobb–Douglas but he does not say what the " capital " which has a unit elasticity of substitution with labour consists of. In each economy, with a different rate of profit, the pattern of relative prices of different products must be quite different (unless a fresh lot of fudge or butter is introduced into the assumptions) and the physical specifications of equipment are different (even in the looms-to-weaver kind of technical progress, looms at a later date, that can be minded by fewer weavers, are in some way different from earlier ones). Does the Cobb–Douglas nature of his production function mean that in all the economies, by a queer fluke, the share of wages in net value of output is the same? And if so, why is it interesting? Or does it mean that there is some idiosyncrasy in the technical conditions (in terms, say, of the number of man-years of work required, in each economy, to provide a man with the latest equipment for producing commodities) which makes " labour embodied " in the stock of equipment proportional to output in the various economies? Or what?

There is also a short-period relation between employment and output, which we may call a *utilisation function*, to distinguish it from a production function. It shows product per man falling as more labour is applied to given plant. In each economy, therefore, there is an intensive and an extensive margin, the marginal physical product of labour on the best plant in existence in each line at any moment being equal (under perfect competition) to the average product of the oldest, the value of both being equal to the wage. This short-period utilisation function has the same shape in each economy, and retains its shape as productive capacity grows. It, also, is said to be Cobb–Douglas, which presumably means that, in perfect competition

with the value of the marginal product of labour in each line equal to the wage, the share of the wage bill in the total value of output is the same at each level of utilisation.

All this seems to be a perfectly unnecessary piece of piety that complicates the argument without enriching it.

Let us concentrate on any one economy, chugging along with a constant rate of profit. From a highly fashionable proposition in neo-neo-classical economics, we know that, when the rate of profit is higher than the rate growth, consumption exceeds the wage bill. Suppose that a planner took over an economy in this condition and decided to impose a greater rate of saving upon it for a time, so as to reach a position with a higher level of consumption, at some date in the future, than would have been reached on the former path, while continuing from then on to realise the former growth rate. (The growth rate that can be permanently maintained is the " natural " rate given by autonomous technical progress.) The planner cuts down consumption and transfers some workers permanently from the commodity sector to the investment sector. It takes a period equal to the length of life of plant for the extra investment to build up a balanced stock of productive capacity at the higher level. During this period, with the larger output of the newest type of plant, more old plant than formerly has to be scrapped to release labour to man it. Average output per head in the commodity sector is rising at a faster rate than that given by technical progress. There is no need to bring the mysterious production function into the argument. Output per head rises because the proportion of the newest type of equipment in the total stock is increasing. When a balanced position is reached again the length of service life of equipment has been reduced, all plant older than the new maximum age has been scrapped and the economy has settled down to steady growth once more, having made a step up above the old path.

In such a case we could reckon the cost of making the change in terms of consumption forgone during the transition from the old path to a higher one, and so arrive at the marginal productivity of investment from the point of view of society.

This is not how Professor Solow looks at it. He considers the effect of making a little more investment in one year only, and allowing additional consumption thereafter to carry the economy back to its old path.

To see what this involves we may take a simplified example. Technical progress is fully embodied—at each round of gross investment there is a new blue-print for superior plant that raises the output of commodities per worker employed. Suppose that ten vintages of plant co-exist in the commodity sector, each manned by a cohort of 100 teams of men. One plant employs one team throughout its life. Taking a year as the gestation period for plant, each vintage is used for ten years. At the end of that time the real wage has risen to absorb its whole output and it is scrapped. Now, when plant of vintage V_{10} is being constructed, the capitalists, by consuming less than usual,

release resources to have 101, instead of the usual 100, plants built. Thereafter they return to building 100 a year. To man the extra plant, a team must be taken from vintage V_1 which is entering its last year of life. Next year only 99 teams are released when the remaining V_1 plants are scrapped. A team has to be taken from V_2 to man the hundredth V_{11} plant, and so on until V_{10} enters the last year of its life. One team is then transferred to V_{19}. At the end of the year the remaining 100 teams are released, and go to V_{20}. The normal position is then restored.

Now, the additional output, over and above what would have been available without the extra V_{10} plant, consists in the first year of the output of one V_{10} team minus the output of one V_1 team. The V_1 output was scarcely more than the real wage of a team at the rate then ruling. Thus the additional output this year is equal to the quasi-rent on a V_{10} plant in the first year of its life. Next year the additional output is the output of a V_{10} team minus the output of a V_2 team, which is approximately this year's wage. It is thus equal to the quasi-rent on a V_{10} plant in the second year of its life. And so forth. The additional output, over the ten years, is equal to the series of quasi-rents of a plant, which yields the normal rate of profit on its initial cost. Thus (assuming that the economy was flexible enough to permit one extra plant to be built without additional cost) the extra consumption is equal to the rate of profit on the extra investment.

The argument is certainly ingenious, but what is it supposed to prove? There is a suggestion that Professor Solow thinks that it proves that the rate of profit must be higher when the pace of technical progress is faster. This is evidently not correct. A higher g (other things equal) requires a larger proportion of gross investment to output, but this may be offset by a larger proportion of profits being saved, so that the rate of profit is no higher in a high-g economy than in a low-g economy. In the low-g economy the difference in productivity between one vintage of plant and the next is lower than in the high-g economy, but the greater consumption out of profits depresses the real wage and makes the life of plant longer. Thus the difference between the output of the latest and the oldest plant at any moment is no less than in the high-g economy.

The rate of profit is constant because the rate of accumulation (which is here equal to g) and the excess of consumption over the wage bill are such as to keep it so. Professor Solow has managed to find a marginal something that is equal to it, and so has satisfied his piety in the manner of those modern parsons who say that they believe in the Virgin Birth, but only in a Pickwickian sense.

III

In the third lecture Professor Solow sets out to find, from actual statistics, the production function which piety obliges him to say that he believes to exist. However, it turns out that the production function is in terms of

labour and the " effective stock of capital." This effective stock of capital is the actual plant in existence weighted by its productivity. Thus as output per head gradually rises with technical progress, whether embodied or not, the effective stock of capital grows.

Now, Professor Solow purports to be able to divide the rate of growth of output per head between the contribution due to technical progress and a contribution due to the increase in " capital." He works out what increase in " capital " would have produced the observed increase in output per head if there had been no technical progress. Here is a mystery indeed.

The clue seems to lie in the short-period utilisation function. With given plant in existence, in perfectly competitive conditions, a reduction in employment leads to a rise in output per head. The marginal physical product of labour in each line of activity rises, for the least efficient plant is put out of action and the intensity of cultivation of more efficient plant reduced. (If there were not short-period diminishing returns there could not have been perfect competition in the first place.) It seems that having postulated a short-period utilisation function of a particular form, Professor Solow concludes that a comparable rise in output per head would take place if the ratio of " capital " to labour were increased by investment, with constant employment. To adapt Sir Dennis Robertson's example, nine men with nine spades are digging a hole; dismiss eight; then we are to deduce from the productivity of one man with all nine spades what his productivity would be if he were working a bulldozer.

In his first lecture Professor Solow seemed to admit that it is impossible to describe the plant in existence at any moment as a quantity of capital. It is a specific stock of equipment of various kinds, built in various past phases of technical development. How can we deduce from actual outputs with different amounts of employment (which might be discovered over the course of short-period fluctuations) what productivity would have been if there had been no technical progress in the past, or what plant would be added to the stock if investment now took place without technical progress in the future?

It seems as though Professor Solow has, after all, never really emerged from his butter economy, where future and past melt into one. If everyone except me is perfectly happy to stop there, I wish them joy.

The upshot of the statistical investigation appears to be that the rate of profit is about the same in the United States as in Germany, and in both much above the rate of growth. This indicates that the length of life of obsolescent plant is above the optimum and that more investment, matched by more saving out of profits, would be a jolly good thing. With this we can all agree.

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