political economy *Studies in the Surplus Approach*

volume 1, number 1, 1985

contents

The Theory of Compensation: a Case of Alternative Economic Paradigms*

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Introduction

According to Schumpeter, it was Marx who gave the name Theory of Compensation to "the theory that the working class is being compensated for initial suffering, incident to the introduction of a labour-saving machine, by favourable ulterior effects"[1].

The problem is to know whether technological unemployment, i. e. a lowering in employment caused by the introduction of new machinery in the productive process, can be reabsorbed spontaneously by the economy and what the new level of the wage rate will be. This problem played a crucial role in the theoretical debate of the last century because of its enormous practical relevance. As often happens in these circumstances, the economists of the day split into two factions, one for and the other against "compensation".

The debate died down only after the marginalist theory asserted itself. As Schumpeter states: "The controversy that went on throughout the nineteenth century and beyond, mainly in the form of argument pro and co "compensation", is dead and buried; ... it vanished from the scene as a better technique filtered into general use which left nothing to disagree about"[2].

The purpose of this paper is to show that, besides the fact that the controversy is by no means "dead and buried", the different conclusions

* This is an abridged version of a paper originally published in Italian on the *Giornali degli economisti e annali di economia,* n° 3-4, 1975.

[1] J. A. SCHUMPETER, *History of Economic Analysis,* London, George Allen & Unwin, 1954, p. 683.

[2] *Ibid.,* p. 684.

reached by Ricardo and Wicksell, the two main representatives of the two opposing streams of thought on technological unemployment, depend not on the use of a "better technique", but on the use of a different theoretical framework. In other words, our attempt is to show that the "paradigms", on which the Ricardo's and Wicksell's analysis are based, imply different conclusions, even though the same phenomenon is investigated.

No attempt is made here to reconstruct the historical development of the controversy. Our main references are the chapter *On Machinery* in Ricardo's *Principles* and Wicksell's discussion of *The Influence of Technical Inventions on Rent and Wages* in his *Lectures on Political Economy*. The only digression will be a comment on Marx's treatment of the problem of compensation to demonstrate some intrinsic shortcomings of the labour theory of value.

1. THE MODEL

A proper assessment of the controversy between Ricardo and Wicksell over technological unemployment presupposes a reformulation of the problem. The theoretical framework here adopted is that of the surplus approach, whose roots go back to classical political economy as Sraffa says in *Production of commodities by means of commodities*[3].

To begin with, let us suppose that our economic system includes only two industries or productive branches (manufactures). The first produces commodity "a" and the second commodity "b". Each commodity is produced by means of the other commodity and labour. Both commodities are "basic", i. e. they enter directly or indirectly into the production of the other commodity. Labour enters directly into the production of both commodities. Wages are paid at the end of the production cycle. The capitalist obtains a rate of profit proportional to the value of the advanced means of production. Gross production of every commodity is enough to replace the means of production worn out during the production cycle and, where the case may be, to provide a surplus: the economic system is therefore in a self-replacing state. Net product is distributed between wages and profits.

Moreover, let us suppose that only circulating capital is used in our economic system. That assumption must be justified both in relation to Ricardo and Wicksell. In Ricardo's example, technological unemployment was caused by a change in the ratio between fixed and circulating capital; where circulating capital consisted only of advanced wages. Nevertheless,

[3] Cf. P. SRAFFA, *Production of Commodities by means of Commodities*, Cambridge, Cambridge University Press, 1960, Preface.

as Marx clarifies in his discussion on the Theory of Compensation[4], even ignoring fixed capital the unemployment caused by the introduction of a new method is possible when variable capital (consisting in advanced wages) is replaced by constant capital (the value of the means of production). Yet, Wicksell totally ignores capital as a factor of production in his critique of Ricardo and maintains that the effects on production and employment caused by a new machinery[5] will not change in the more complicated case where capital is taken into consideration as such. Therefore the adoption of a model explicitly providing for circulating capital seems legitimate even in relation to Wicksell.

Now, we can write down the following system of two equations:

$$(A_a p_a + B_a p_b)(1 + r) + L_a w = A p_a \qquad [1]$$

$$(A_b p_a + B_b p_b)(1 + r) + L_b w = B p_b \qquad [2]$$

where A_a and B_a respectively denote the quantities of commodities "a" and "b" needed to produce quantity A of commodity "a". The same holds for A_b and B_b in relation to quantity B of commodity "b". In their turn, the coefficients L_a and L_b denote the quantity of labour required to produce A and B respectively. Moreover, following Ricardo very closely we can imagine that the real wage rate (w) is given by conditions largely exogenous to the economic system: for instance the standard of living of the working class, this being the result of both physiological and historical conditions. Finally, let us take commodity "a" as the standard of value for wages and prices: we therefore put $p_a = 1$. At this point, only two unknowns are left: the rate of profit r and the price p_b. The system is determined: the number of equations is equal to the number of unknowns.

In this system of equations, quantities A_a, A_b, A, B_a, B_b, B and L_a, L_b are considered as given: they denote a method of production for commodity "a" and "b" respectively. Nevertheless, during our discussion we shall be obliged to take into consideration changes in the quantities produced. To simplify the analysis it would be helpful to rewrite the first system as follows:

$$\lambda_a [(A_a + B_a p_b)(1 + r) + L_a w] = [A] \lambda_a \qquad [3]$$

[4] K. MARX, *Capital,* Vol. I (1st edition 1867), Engl. Trans., London, Lawrence & Wishart, 1977, p. 412.

[5] — "Machinery — explains Wicksell — in addition to having the quality of being, or representing, capital..., also possesses the quality of modifying the conditions under which labour and land replace each other at the margin of production. In other words, it may alter their relative marginal productivities and thereby, according to our theory their shares in the product. It is with this characteristic of machinery that we shall now concern ourselves" (K. WICKSELL, *Lectures on Political Economy,* 1st ed. 1926), Engl. transl., London, Routledge & Kegan Paul Ltd, 1967, Vol. I, p. 134).

$$\lambda_b \left[(A_b + B_b p_b)(1 + r) + L_b w\right] = \left[B p_b\right] \lambda_b \qquad [4]$$

where λ_a and λ_b are two coefficients multiplying the right-hand and left-hand sides of the two equations. The values of p_b and r will not be modified by these two coefficients: the value of relative prices and the rate of profits depend solely on the method of production used and not on the quantity produced. Every increase or reduction in the quantities produced occurs with no changes in the method of production; i. e., every industry expands or shrinks at constant returns to scale. In that way, we can mantain a clear distinction between causes affecting changes in methods of production and causes affecting changes in quantities produced in every industry.

2. THE CLASSIFICATION OF INNOVATIONS

One entrepreneurial innovation consists in achieving a rate of profits higher than that ruling on the market by introducing a new method of production. The question is now what technical conditions need to be fulfilled for a new method to become profitable.

First of all, let us calculate the solution for equations [1] and [2]. If we get p_b from [1] we can write down (remembering that $p_a = 1$):

$$p_b = \frac{A - L_a w - A_a (1 + r)}{B_a (1 + r)} \qquad [5]$$

Since the wage rate is given, price p_b is a function of the rate of profit alone. This function may be represented[6] in the positive sector, by segment HG in fig. 1.

This function decreases as the value of r rises. It has a maximum value when $r = 0$, in the positive sector, and then it crosses the x-axis.

[6] The denominator of [5] is zero when $r = -1$. Therefore there is a vertical asymptote in point $(p_b = 0; r = -1)$.

When r tends to infinity, the limit of the function is equal to $-\frac{A_a}{B_a}$. Therefore function [5] has a horizontal asymptote for that value.

At point H, for $r = 0$, the value of p_b is:

$$p_b = \frac{A - A_a - L_a w}{B_a}$$

At point G, for $p_b = 0$, the value of r is:

$$r = \frac{A - A_a - L_a w}{A_a}$$

Let us consider now the behaviour of p_b as a function of r, as deduced from equation [2]. It is:

$$p_b = \frac{L_b w + A_b (1 + r)}{B - B_b (1 + r)} \qquad [6]$$

This function rises continously from a minimum value, in the positive sector, corresponding to a zero rate of profit[7], as function MF in fig. 1.

It tends to infinity for

$$r = Q = \frac{B - B_b}{B_b};$$

i. e. the maximum rate of reproduction of commodity "b". At this point, the solution to the system of equations [1] and [2] lies in the values of r and p_b common to functions MG and MF in fig. 1.

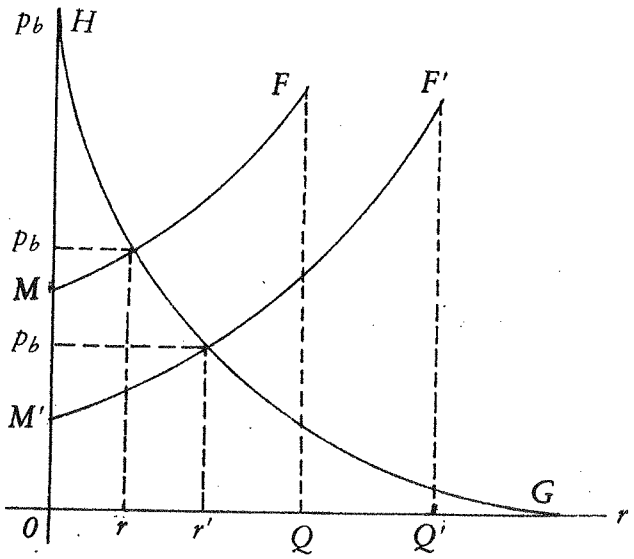


Fig. 1

[7] For $r = 0$ the value of [6] is:

$$p_b = \frac{L_b w + A_b}{B - B_b}$$

The numerator of that function is positive because the two coefficients L_b and A_b are positive; moreover $B - B_b > 0$ because it is assumed that the system is in a self-replacing state.

Now let us consider an innovation in the industry producing commodity "b". Five kinds of innovations can be identified.

a) The first type of innovation consists in obtaining a greater quantity of B, for instance B', by means of the same quantities A_b, B_b and L_b. In Fig. 1 the new behaviour of the price in relation to the rate of profit, given the new value of B, is represented.
The value of Q increases to

$$Q' = \frac{B'\text{-}B_b}{B_b},$$

and the value of OM falls to OM'.

Therefore the rate of profit rises from r to r': by the same quantity of labour and means of production a greater quantity of commodities is produced. Moreover, the rate of profit in the new situation is not raised only in the industrial branch adopting the new method, but in the whole economy. Indeed, since the price of "b" has fallen to p'_b, the costs of production in industry producing "a" and employing the quantity B_a of "b" must fall as well.

b) The second type of innovation consists in discovering a method reducing the quantity of commodity "b" used in production of itself. The new technical coefficient becomes now $B'_b < B_b$. This innovation produces consequences quite similar to those described for the previous one and Fig. 1 describes the new situation as well.

c) Thirdly we may consider an innovation consisting in obtaining the same quantity of "b" using a reduced quantity of labour, for instance $L'_b < L_b$. This change may be represented as follows:

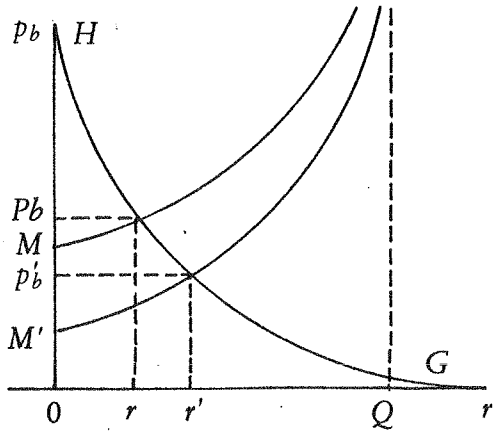


Fig. 2

The intersection point with the y-axis shifts from OM to OM'. The value of Q does not change. The price falls to p'_b and the rate of profits increases to r'.

d) The fourth type of innovation consists in reducing the quantity of commodity "a" employed in producing "b", i. e. $A'_b < A_b$. This change is quite similar to the previous one and may be represented by Fig. 2.

e) The last type of innovation concerns a simultaneous change in two or more technical coefficients. The only condition to be respected is that the new method must give a higher rate of profits if it is adopted (and consequently a reduced price p_b).

3. EFFECTIVE DEMAND AND EMPLOYMENT

Let us now suppose that the quantity of any commodity brought to the market is equal to its "effective demand" — i. e. to the quantity of it which can be sold at the natural price[8] — and for our purposes let us consider effective demand as referring to the *net* production of any commodity. It is possible therefore to write the following equations:

$$ED_a = A\lambda_a - (\lambda_a A_a + \lambda_b A_b) \qquad [7]$$

$$ED_b = B\lambda_b - (\lambda_b B_b + \lambda_a B_a) \qquad [8]$$

Moreover we shall assume that our effective demand, equal to the physical surplus of every commodity, does not change when an innovation is introduced and is only a demand for consumption goods: our economy reproduces itself and net investments are equal to zero.

With this notion of effective demand we gain the advantage that the sphere of production is kept separate from that of consumption. Any change concerning the sphere of production will affect the value of technical coefficients A, A_a, etc. Any change regarding consumption will affect the value of ED_a and ED_b: the level of effective demand will therefore determine the volume of production and employment[9].

[8] It is worth recalling that this notion of effective demand goes back to Adam Smith's bk. I, ch. VII of *The Wealth of Nations*, and that is has some aspect in common also with the Keynesian concept of effective demand.

[9] We may note that relations [7] and [8] show a normal situation: in other words, it should be explained how either the number of firms or the volume of production change when effective demand changes. In connection with this problem, it seems that the only satisfactory reply so far is Smith's distinction between natural and market prices. If effective demand, for instance ED_b, increases, the quantity of commodity "b" brought to the market is no longer sufficient to satisfy the buyer's requests. Market price p^*_b will rise above natural price p_b (as determined by the two equations [1] and [2]). If the

To begin with, let us discuss the effects on employment caused by an innovation, taking effective demand as given (as Marx seems to suggests[10] in his discussion). That assumption is justified, as a first approach to a more complex examination, by the fact that effective demand depends on various factors (for instance, relative prices, per-capita income, expectations, etc.) the study of which should be kept distinct from changes in the sphere of production. If we agree to this assumption, we can give a proper assessment of some compensationist's objection which relies on further accumulation. A change in effective demand and a new accumulation are incidental effects which do not necessarily happen in our economy. But it must be clear that we do not rule out the possibility of dealing with these problems at a further stage of the analysis.

After adopting this viewpoint, let us now consider the effects caused by the five types of innovation listed above.

a) When $B' > B$, all other technical coefficients being unchanged, and remembering that ED_b does not move, from [7] and [8] it follows that there is a fall in λ_a and λ_b. Indeed, let us suppose, for a while, that they do not change. Equation [8] is not respected. On the other hand, a fall in λ_b could balance equation [7] (because it comes out $ED_a > A\lambda_a - [\lambda_a A_a + \lambda_b A_b]$). A fall in coefficient λ_a is therefore necessary; but that fall will cause a new decrease in coefficient λ_b in [8]. The last change, nevertheless, is, percentage-wise, smaller than the previous one: therefore sooner or later equality will be reached in both equations.

The improvement in the method for producing "b" thus entails a fall in the production index of that industry. In consequence, since a certain quantity of "a" is needed for producing "b", the quantity produced in industry "a" must decrease. A certain number of workers who were employed before innovation now become redundant.

b) Let us now suppose that $B'_b < B_b$. The effects are quite similar to the previous case. The effective demand being given, λ_a and λ_b must fall. There will be more unemployment.

c) The third type of innovation concerns a fall in coefficient L_b. In such a case, and only in such a case, since labour coefficients do not enter into equations [7] and [8], no change in indices λ_a and λ_b is required. In consequence, with this type of innovation no diminution in the quantity produced by the two industries occurs, but of course unemployment will increase.

wage rate does not change, in industry producing "b" the rate of profit is now higher than the natural one, therefore $r_b > r_a$. This difference in the rates of profit will bring capital and entrepreneurs into the industry. Finally, when the quantity of commodity "b" brought to the market is enough to satisfy the new effective demand, the market price will fall to the natural price level and the rates of profit will be again equal in every branch of the economy.

[10] K. MARX, *op. cit.*, p. 417.

d) The fourth type of innovation concerns a fall in coefficient A_b. If the quantity of commodity "a" entering into the production of "b" decreases, production of commodity "a" must also be reduced. But since commodity "b" enters into the production of "b", a diminution in "b" production is unavoidable. The coefficients λ_a and λ_b must therefore fall. Gross production in the two industries and employment will fall as well.

e) The last type of innovation, where an alteration in two or more technical coefficients is possible, is the only one which could give rise to an increase in employment. Indeed it could happen that a fall in A_a and B_b, entering the production of B, is coupled with an increase in the labour required by the new method, L'_b. In that case, the possibility of an increase in the total labour employed in the economy to satisfy a given effective demand may be allowed[11]. Of course, the opposite should not be excluded. No *a priori* indication on the direction of change in gross production and employment can be given.

We can conclude that, with a given effective demand, the first four types of innovations save labour either directly or indirectly. Among these first four innovations those modifying technical coefficients out of labour coefficients also reduce the two industries' production indices and therefore the gross production of some industries as well. The only kind of innovation which does not change gross production in every industry is the one reducing only the labour required for a given volume of production. With the first four types of innovation the only possibility, with a fixed wage rate, for dismissed workers to be reabsorbed is if effective demand increases. Given the effective demand and given the wage rate, the only way of increasing employment is to introduce a method of production requiring more labour and saving other means of production.

4. INNOVATIONS FOR "LUXURY" COMODITIES

Luxury commodities give rise to a special case. They are products "which are not used, whether as instruments of production or as articles of subsistence, in the production of others"[12].

In addition to commodities "a" and "b", let us imagine production of a

[11] This statement may be proved by a simplified example. Let $ED_b = 0$, but let us assume a positive effective demand for "a". Any innovation allowing a greater rate of profit, but at the same time reducing the net product per worker (measurable in physical terms, since only effective demand for "a" exists) gives rise to a greater volume of employment, if the same effective demand is to be satisfied again (see also § 6).

[12] P. SRAFFA, *op. cit.*, § 6, p. 7.

third commodity "c" so that the production equation, to be added to equations [3] and [4], is as follows:

$$\lambda_c[(A_c + B_c p_b)(1 + r) + L_c w] = [C p_c] \lambda_c \qquad [9]$$

Commodity "c" is produced, but it does not enter into the production of any other commodity. Effective demand for "c" is:

$$ED_c = \lambda_c C$$

it is therefore equal to gross production.

As Sraffa points out: "These products have no part in the determination of the system. Their role is purely passive. If an invention were to reduce by half the quantity of each of the means of production which are required to produce a unit of a 'luxury' commodity of this type, the commodity itself would be halved in price, but there would be no further consequences; the price relations of the other products and the rate of profits would remain unaffected"[13].

Nevertheless, even if p_b and r do not change when an innovation is introduced, "a" and "b" production must fall, since in the new situation a lower quantity of those commodities is needed to get the same quantity of "c", whose effective demand can be assumed not to have changed. Not only is the labour employed in industry "c" halved, but a certain number of workers employed in non-luxury production will now be redundant[14].

5. CHANGES IN THE WAGE RATE AND IN THE METHODS OF PRODUCTION

For a full examination of the effects of innovations, changes in the wage rate following the introduction of a new labour saving method must be taken into consideration. We therefore need to introduce a new classification of innovations to be able to assess the profitability of a certain method when the wage rate is changed. The problem is to extend the classification of innovation from the case in which the wage rate is given to the full range of the wage-profit frontier.

The problem needs to be simplified further. Let us produce only a quantity greater than zero of net product of commodity "a" and suppose that effective demand for "b" is equal to zero, i. e., the quantity produced

[13] *Ibid.*, § 6, pp. 7-8. We should remember that the price of the commodity will be halved in the case in which — as Sraffa assumes here — the goods necessary for the subsistence of the workers are included amongst the means of production.

[14] Of course, it is possible to think of innovation for "luxuries" augmenting the total quantity of labour employed in production.

of commodity "b" is just enough to replace the quantities worn out in production. Finally, let us imagine that "b" is the only means of production. We can therefore write down the following system of equations[15] taking one unit of net product of "a" as the standard of measure:

$$B_a p_b (1 + r) + L_a w = 1 \qquad [10]$$

$$B_b p_b (1 + r) + L_b w = p_b \qquad [11]$$

When effective demand for "a" is greater than one we are at once able to say that in the industry producing "a" the index λ_a is equal to ED_a and industry "b" the index[16] is equal to:

$$\lambda_b = \frac{B_a}{1 - B_b} \cdot ED_a \qquad [12]$$

From equations [10] and [11] we can draw the wage-profit relation, that is:

$$w = \frac{1 - B_b (1 + r)}{L_a + (L_b B_a - L_a B_b) (1 + r)} \qquad [13]$$

This relation may be represented in Fig. 3.

We can now look at some important property of function WR, where OW shows the maximum wage rate when $r = 0$. Every point on the WR shows a possible relation between wages and profits in the economic system in question. The segment OW measures the net physical product per worker obtainable, because we imagined that only one commodity is produced for effective demand[17]. Consequently, given a certain wage

[15] The assumptions here adopted are the same as in P. GAREGNANI, "Heterogeneous Capital, the Production Function and the Theory of Distribution", *The Review of Economic Studies,* 1970, pp. 407-436, for the system discussed in the first two sections of his paper, to which the reader may usefully look for other properties of the system.

[16] Given $ED_b = 0$, we can write:

$$ED_b = 0 = \lambda_b - \lambda_b B_b - \lambda_a B_a$$

and therefore:

$$\lambda_b = \frac{B_a}{1 - B_b} \cdot \lambda_a$$

[17] Indeed, remembering that only a physical unit of "a" is produced, if $r = 0$, we can get:

$$w = \frac{1 - B_b}{L_a (1 - B_b) + L_b B_a} = \frac{1}{L_a + L_b \lambda_b} = \frac{\text{Net product}}{\text{Labour employed in net production (directly and indirectly)}}$$

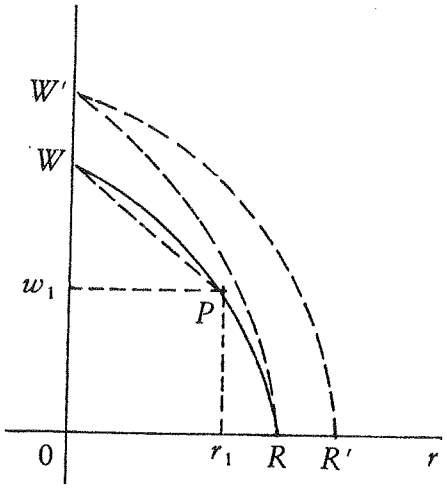


Fig. 3

Ow_1, the segment w_1W measures the quantity of the net product per worker paid to capitalists. Therefore, the tangent of the angle w_1PW measures the value, in terms of commodity "a", of capital per worker (k), when the wage rate is Ow_1 (the value of capital per worker is

$$\frac{\text{profit per worker}}{\text{rate of profits}} = \frac{w_1 W}{Or_1}).$$

Moreover, the bending of WR depends on the value of the denominator[18] of [13] i. e. $(L_b B_a - L_a B_b)$. When

$$\frac{B_a}{L_a} = \frac{B_b}{L_b},$$

the wage-profit relation is a straight line. In this case, a change in the rate of profit will cause a change in the value of capital and in the amount of profits, in the two industries, to the same extent that the labour costs change in the opposite direction: in this case relative prices do not depend on income distribution. Commodities are exchanged on the market ac-

[18] The sign of the second order derivative of function [13] depends in effect on the sign of the denominator.

cording to the quantity of labour they embody. Moreover, since the ratio between the quantity of labour and the means of production is the same in both industries, we can say that in reality the commodity produced is the same and is used both as a capital good and as a consumption good.

When

$$\frac{B_b}{L_b} > \frac{B_a}{L_a}$$

the WR relation is concave (as in Fig. 5). Since the ratio between "capital" and labour is greater in industry "b" when the basic commodity is produced, an increase in the profit rate and a diminution in the wage rate will cause an increment in total costs in that industry compared with industry producing "a". Therefore p_b will increase when r increases. On the contrary, when

$$\frac{B_a}{L_a} > \frac{B_b}{L_b},$$

p_b decreases when r increases.

We are now able to consider the effects caused by a new method of production on the wage-profit relation. Two fundamental kinds of innovation must be distinguished. The first type should be denominated "innovations without ambiguities", in the sense that for any level of the wage and profit rate they come out as more convenient than the old method. In our simple case, an instance of this kind of innovation is given by a diminution either in coefficient L_b or in coefficient B_b (in the more general case previously discussed this kind of innovation includes the first four types of the classification). When the quantity of the labour employed L_b decreases, the net product per worker increases from OW to OW', but the maximum rate of profit will remain unchanged at the level OR. When the technical coefficient B_b decreases, an increase both in net product per worker and in the maximum rate of profits will occur. Moreover, for every rate of profits a greater wage rate may be paid[19].

[19] Consider the following equation:

$$OW = \frac{1 - B_b}{L_a + (L_b B_a - L_a B_b)}$$

The first order derivative $(\frac{\delta OW}{\delta B_b})$ is negative. For every decrease in B_b, OW increases consequently.

Moreover, let us multiply both numerator and denominator by the same factor $(1 + r)$. If we ignore L_a for the moment, we can easily see that the new method gives a higher wage rate.

A second kind of innovation could be defined as "ambiguous". Indeed when more technical coefficients change simultaneously it may happen, besides the obvious case in which the WR relation lies completely on the external side of the old WR, that for some values of the wage rate (or the profit rate) the new method comes out as more convenient than the old one, but for some other values of the wage rate the old method comes back as more profitable again. The situation is illustrated in Fig. 4.

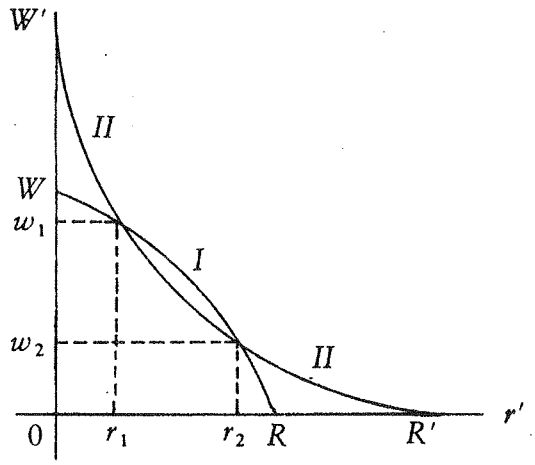


Fig. 4

Relation $W'R'$ shows all the rates of profits (or wages) obtainable with the new method. It is immediately possibile to see that when the wage rate is included between Ow_1 and OW' the second method is more convenient. If the wage rate is included between Ow_1 and Ow_2, the old method comes out as the most convenient, since it allows higher rates of profits. For a wage rate below Ow_2 the second method is again more profitable[20].

6. THE EFFECTS OF MACHINERY ACCORDING TO RICARDO

With the help of our economic model, let us now consider Ricardo's example. Ricardo considers an innovation increasing "net income", i. e.

[20] For the problems concerning the choice of the methods of production see P. GAREGNANI, *op. cit.*, pp. 410-12.

profits, and at the same time diminishing "gross income", i. e. total production. The difficulty of understanding this statement correctly is twofold: *a*) Ricardo considers absolute quantities and not technical coefficients, as we do; *b*) Ricardo considers only one productive branch and not the whole economy, as his example shows when the rate of profits returns to the old level, after innovation, whereas in the case of an innovation concerning a basic commodity this effect is not possibile (on the other hand Ricardo has no intention of considering luxury commodities, since he states clearly that the capitalist is engaged in manufacturing "necessaries").

Therefore let us assume that commodities are exchanged according to their quantities of embodied labour (that is

$$\frac{B_a}{L_a} = \frac{B_b}{L_b})$$

and write the equation regarding production of commodity "b":

$$B_b p_b (1 + \overset{\uparrow}{r}) + \underset{\downarrow}{L_b w} = \underset{\downarrow}{B p_b}$$

Probably Ricardo simply meant that an innovation should reduce the quantity produced B (the gross product) together with a reduction in the quantity of labour employed L_b. These changes are compatible with an increase in the rate of profit r (the net revenue Ricardo refers to is the share of net product belonging to profits).

In our case, since we always produce one unit of net product of "a", the quantity to be produced of "b"depends on the needs of the whole economy. But if it is not possible to change the B coefficient, we can nevertheless imagine that more units of B_b are needed to produce B. This kind of change will cause a fall in the maximum rate of profit

$$R = \frac{1 - B_b}{B_b}.$$

Afterwards, in the new system of production, commodities are no longer exchanged according to their quantities of embodied labour (since we have

$$\frac{B_a}{L_a} < \frac{B'_b}{L_b}).$$

Therefore, the *WR* relation is no longer a straight line, but a concave one. Graphically it is as follows:

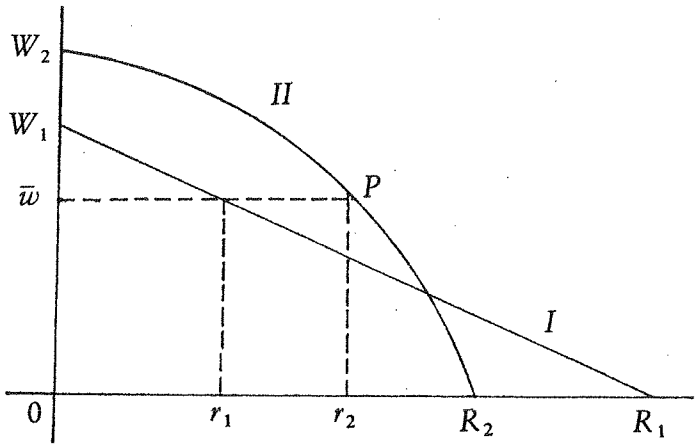


Fig. 5

In Fig. 5, I shows the old method and II the new one. At a given wage rate $\bar{w}$, we can see that the new method is more convenient. Moreover, the new method can have a net product per worker

$$q = \frac{1}{L},$$

where L is the whole quantity of labour employed in the system, that is either higher or lower[21] than the old one (that is $OW_2 > OW_1$ or $OW_2 < OW_1$). This result is not surprising since we are dealing with an "ambiguous" innovation.

This analysis confirms only some of Ricardo's statements. As a general rule, it is not true that when a new method is introduced "there will necessarily be a diminution in the demand for labour"[22]. Given the following relation between effective demand and employment:

$$ED_a = qL \qquad [14]$$

we can easily see that when the net product per worker increases, fewer labourers are needed to satisfy the same demand, but if it decreases more

[21] We remember that $L = \lambda_a L_a + \lambda_b L_b$ and that if by assumption $ED_a = 1$ we have:

$$L = L_a + L_b \frac{B_a}{1 - B_b}$$

Therefore L may either increase or decrease since L_b is reduced, by assumption, whereas B_b is raised.

[22] D. RICARDO, *On the Principles of Political Economy and Taxation* (1st ed. 1817), Cambridge, Cambridge University Press, 1966, p. 390.

labourers will be employed. Ricardo considers only the first case, where it is true that the wage fund (Lw) going to workers diminishes. Moreover, the share of net product going to capitalists will increase[23]. The only possibility, in such a case, for unemployment to be reabsorbed is, as Ricardo correctly says when he takes accumulation into account, if effective demand increases.

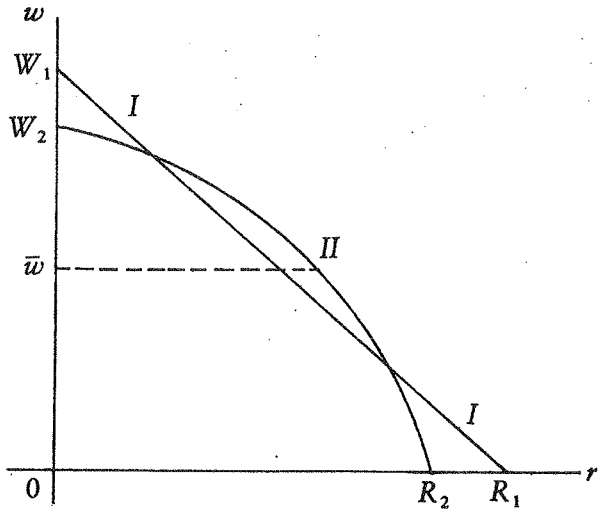
Nevertheless, Ricardo is wrong in thinking that a decrease in the gross product of a firm implies a decrease in the gross product for society. It is not true that the innovation he considers reduces "the gross produce of the country". Since it must be assumed that industrial production may increase without hindrance, sooner or later the quantity brought to the market will be enough to satisfy effective demand. As we already said, the volume of effective demand must be considered, in principle, independent from changes in technical coefficients (of course, these changes will cause a movement in relative prices, but the study of the effect of relative price movements on effective demand is another problem which is not possible to discuss exhaustively here).

For the same reasons, some criticism should be adressed to Marx as well. On the basis of the labour theory of value it seems obvious to affirm that all innovations reducing commodity prices must also réduce the quantity of labour directly or indirectly embodied in production. Yet we are not interested in absolute prices. A decrease in the relative price of a commodity is compatible with an increase in the absolute quantity of labour required by the system[24]. Let us consider for instance a situation[25]

[23] The ratio between the two shares is measured by the elasticity of the WR function at point P. It is $e = \frac{kr}{w}$, where k = capital per worker.

[24] Price $p_b = \frac{L_b}{L_a}$ may decrease if an increase in L_b is met by a more than proportional increase in L_a.

[25] The situation is as follows:



in which the new method, more convenient at wage rate $\bar{w}$, gives $OW_2 < OW_1$. When the new method II is introduced, employment will increase, not diminish, since the product per worker is now lower.

The possibility of introducing some innovation reducing net product per worker disproves Marx's "infallible law" which states that: "If the total quantity of the article produced by machinery, be equal to the total quantity of the article previously produced by a handicraft or by manufacture, and now made by machineryy, then the total labour expended is diminished"[26]. If effective demand does not change when an innovation reduces the net product per worker, the total amount of employed labour increases.

Generally speaking, if we abandon the labour theory of value, Marx's statement is true for non-ambiguous innovations, according to the previous classification, but is no longer true when more technical coefficients change simultaneously.

7. THE EFFECT OF MACHINERY ACCORDING TO WICKSELL

Wicksell defines technological innovation as a shift in the production function. Therefore, we must first of all examine how a production function may be derived from our analytical tools.

Taking our wage-profit relation as a basis, we need to construct a function connecting the marginal product of labour with the labour-capital ratio (where "capital" means the value of the instruments of production). Let us consider a case in which either commodities are exchanged according to their quantities of embodied labour or (but it is the same thing) production consists in only one commodity produced by itself and labour and the wage-profit relation is a straight line. The slope[27] of this straight line is the value of capital per worker (k).

Fig. 6a may be drawn from Fig. 6b. Given a set of methods for the production of commodity "a", we can see that for high wage rates (for instance those included between q_1 and the ordinate corresponding to E_1) the method with a capital-labour ratio equal to k_1 is adopted. For wage

[26] K. MARX, *op. cit.*, p. 417.

[27] The derivative of the function WR at a point is:

$$\frac{dw}{dr} = \frac{q}{R} = \frac{1 - B_b}{L_a} : \frac{1 - B_b}{B_b} = \frac{B_b}{L_a} = k$$

(remembering that $\frac{B_b}{L_b} = \frac{B_a}{L_a}$ and $p_b = \frac{L_b}{L_a}$ it follows that $\frac{B_b}{L_b} \cdot \frac{L_b}{L_a} = k$).

rates lower than E_1, but higher than E_2, the second method is adopted, with a capital-labour ratio lower than the previous one and so on. In Fig. 6a we can therefore picture a decreasing relation between the wage rate and the labour-capital ratio.

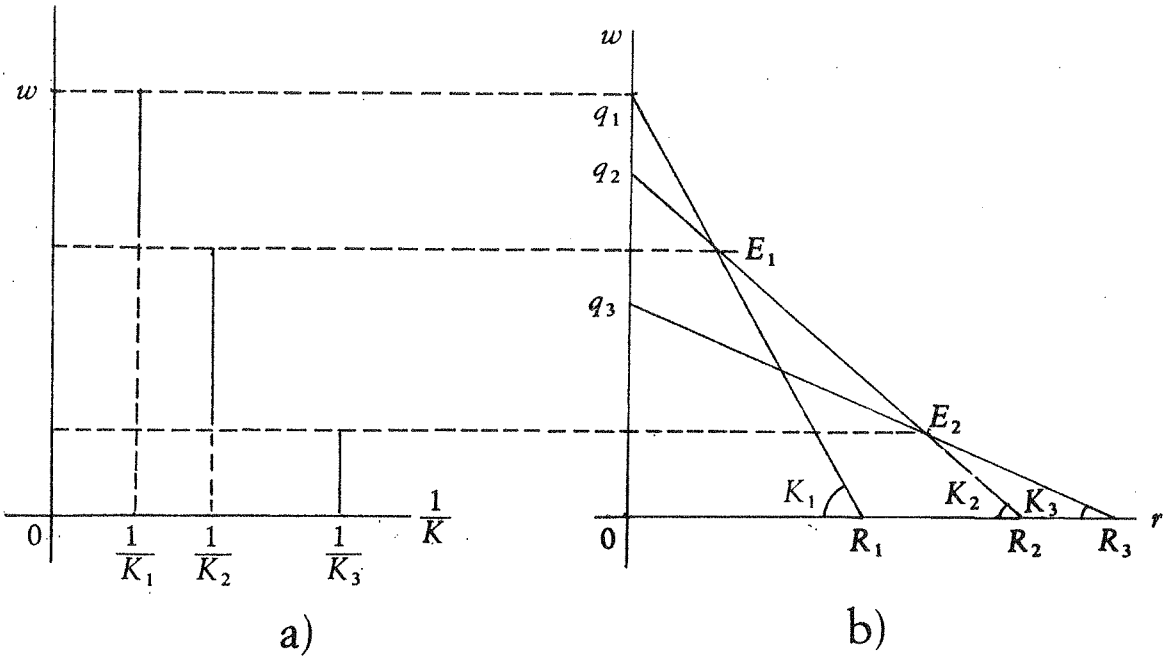


Fig. 6

Now if we assume the existence of a great number of the *WR* relations, we can construct an envelope curve[28] called *EE*. A tangent to a point on that envelope curve specifies a given system of production equations, with a value of the capital-labour ratio equal to the tangent. If we suppose now that the rates of remuneration of the two factors — labour and land in the case of Wicksell, labour and capital in our case — are equal to their respective marginal productivities, we are able to draw, from the envelope curve, the production function.

Fig. 7a is drawn from Fig. 7b with a procedure analogous to the one adopted for Fig. 6. Yet, the marginal product of labour, equal to the wage rate, is put on the ordinate of Fig. 7a. Fig. 7a therefore represents the behaviour of the marginal product and, more generally, the envelope curve shows a production function with constant returns to scale, the

[28] For the construction of this envelope curve cf. P. GAREGNANI, *op. cit.*, section II and III.

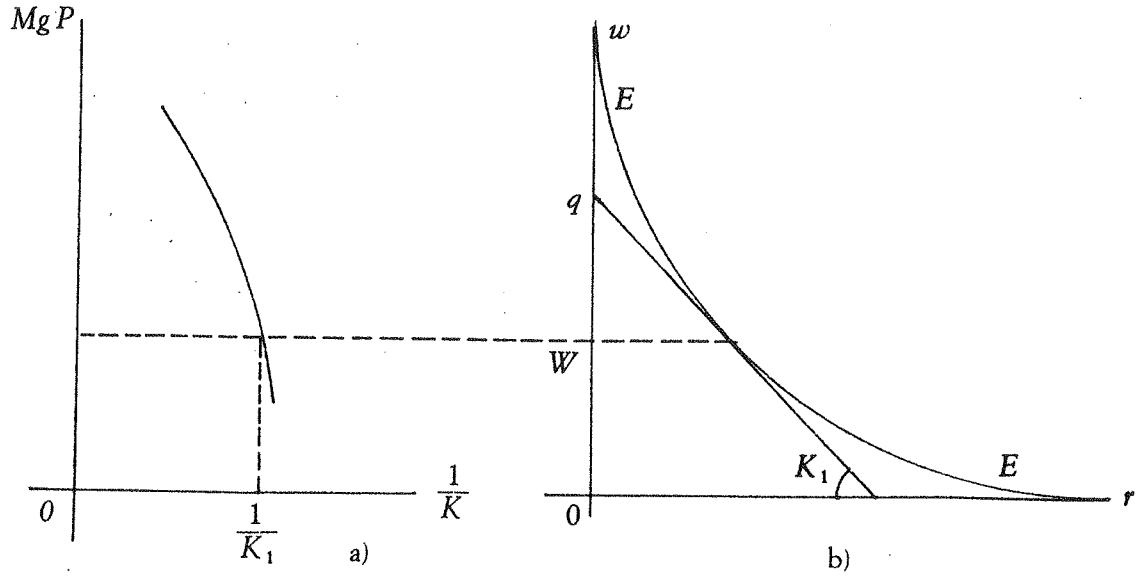


Fig. 7

production being shared between capital and labour according to their marginal productivity[29].

We are now able to show the consequences of an innovation according to Wicksell. The production function will shift in such a way that a new method, with a higher product per worker than the previous one, becomes profitable. The shift is shown in Fig. 8.

Given the envelope curve E_1E_1, the wage rate w_1, equal to the marginal productivity of labour, is determined according to the proportion of the quantity of labour and the quantity of capital existing in the economy. At that wage rate all workers are employed. When a new production function is discovered a new envelope curve E_2E_2 is built. On that curve,

[29] Let us write the following relationship:

$$q = k\,r + w$$

remembering that $q = \frac{1}{L}$ and $k = \frac{q}{R}$, we can get:

$$1 = \frac{1}{R}r + w\,L$$

The value of capital in an economy producing one unit of net product is $K = \frac{1}{R}$ therefore:

$$1 = Kr + Lw$$

We can see that if the wage rate is equal to the marginal product of labour and the rate of profits to the marginal product of capital the whole product is distributed completely between the two factors. The production function must therefore have constant returns to scale.

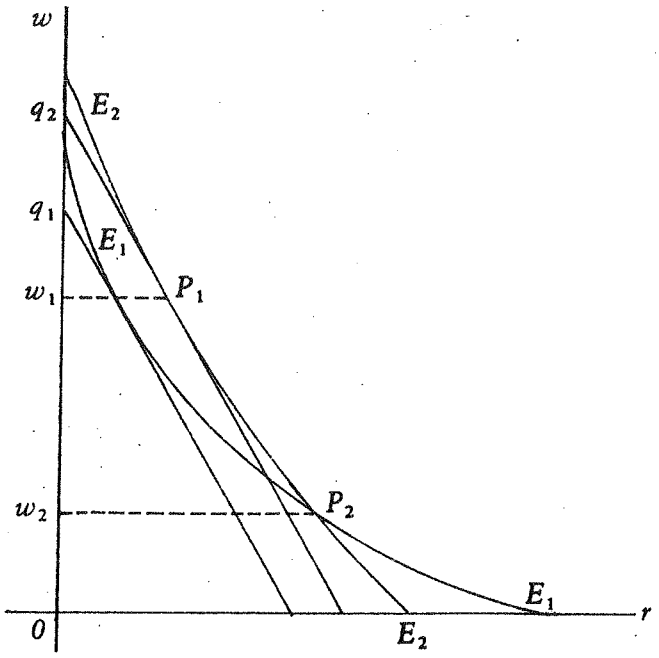


Fig. 8

at the given wage w_1, a method allowing a higher rate of profit and a higher product per worker ($q_1 < q_2$) may be adopted. When the new method is introduced, nevertheless, a certain number of workers become redundant and are dismissed. The competition among these workers looking for a job on the labour market will bring the wage rate down. The process goes on[30] until wages reach w_2, where the rate of profit is equal in every farm, those adopting the old set of methods E_1E_1 and those adopting the new set E_2E_2. At this wage rate all workers will find employment if production increase suitably (i. e., if the effective demand, when the wage rate is w_2, is $ED_a = L_1q' + L_2q''$; where $L = L_1 + L_2$ is the number of workers employed in the economy and q' and q'' represent the productivity of the method adopted in point P_2). Total production must increase because, as Wicksell shows, each worker leaving the old farm finds employment on a new farm where the average productivity per worker is higher[31].

At point P_2 an equilibrium position is reached: production is made with the two methods simultaneously; all workers are employed and a uniform rate of wages and profits rules in the economy.

[30] If the two functions E_1E_1 and E_2E_2 do not intersect, the new equilibrium point is reached when the wage rate falls enough to make a method of the set E_2E_2 profitable. This new method will show a k equal to the one existing before (in P_1). In this case only the new set of methods is adopted.

[31] The type of innovation described by Wicksell implies that the tangent to point P_2 on E_2E_2 has a k ratio higher than the value of the tangent in point P_1. If this is not the case, it is impossible for the economy to reach point P_2, because the full employment of capital and labour will be reached before and all farms will adopt a method of the new set E_2E_2.

8. THE NOTION OF COMPETITION IN WICKSELL AND RICARDO

We are now able to compare Wicksell's analysis with Ricardo's analysis.

First of all, Wicksell ignores the problem of effective demand. In the case in question we saw that production increases when we move from one equilibrium point to another. But Wicksell does not consider the problem of knowing if new production can be absorbed; implicity he assumes that the more is produced the more is sold. Effective demand does not determine the volume of production and employment. It is wage flexibility which allows the adoption of a method with a capital-labour ratio assuring full employment of labour.

In the second place, the consequences of unemployment are quite different in Wicksell as compared with Ricardo, according to the respective theories of the real wage. In Wicksell's analysis the existence of unemployed workers would cause the real wage to fall, because of competition among workers, until unemployment has been reabsorbed. In Ricardo, instead, there is no mechanism by which a fall in the real wage should necessarily bring about an increase in employment, and the influence of unemployment on the real wage is relevant only in the short run; at any rate, the first effect of a reduced wage considered by Ricardo is not on employment but on profits. Generally speaking, we can say that wages in a Ricardian economy depend on conditions whose nature is not exclusively economic (for instance, social and historical customs, the trade-unions' relative strength, etc.). Competition in the labour market mainly has the function of levelling the wage rate in the whole economy: in those sectors in which entrepreneurs offer less than the "natural wage" no worker will accept a job; on the contrary, in the sectors where wages rise above the natural level, workers will enter the industrial branch and bring the wages down to the "natural rate" (as Adam Smith calls it).

When this second kind of labour market works effectively, we can see that, in the case proposed by Wicksell, after the discovery of the new set of methods E_2E_2, the wage rate will not necessarily change even if the new method, with a productivity equal to q_2, is introduced in the economy. Of course, a certain number of workers will be dismissed. Nevertheless, if we admit as Wicksell implicitly does that effective demand may rise until all workers are employed, we can say that production, in such a case, may reach a volume higher than that calculated by Wicksell, when he assumes a free movement in the wage rate. Indeed, the method adopted, when the wage rate is w_1, gives an average product per worker (q_2) which is higher than the average yield produced by the methods profitable at wage rate w_2 (if everybody employs the new technique the average productivity will be $q'' < q_2$).

This remark is important in order to confute Wicksell's statement that

"free competition is normally a sufficient condition to ensure maximization of production"[32]. This maximum Wicksell alludes to is simply the volume produced when wages are allowed to decrease until the combination of methods assuring full employment (with a given capital) becomes profitable. Moreover, we must of course suppose that no obstacles exists to the absorption of this volume of production. When we drop the assumption that effective demand is automatically equal to production, to speak of "maximum production" has no precise meaning. For other wages (given the relation $ED_a = qL$) other "maximum" levels of production are feasible if we assume that all workers are employed: with the set of methods E_2E_2, the higher the wage rate the higher the product per worker and therefore the higher the maximum volume of production for the economic system.

Finally, we should note that Wicksell believes it is impossible to admit that effective demand determines the level of production: in such a case he should abandon the theory that the wage rate is equal to the marginal product of labour when all workers are employed. One could also say that free competition on the labour market pushes towards full employment only if production increases (or decreases) freely. The marginalist theory of production cannot be separated from the distribution theory based on the equality of each factor's income to its marginal product.

To conclude, whereas in the Ricardian theory market competition has only the function of assuring a uniform "natural" rate of wages and profits in the whole economy, in the marginalist theory market competition has other "optimum" implications, which nevertheless do not seem to be justifiable.

9. THE THEORY OF CAPITAL AND THE LABOUR MARKET

Basing himself on the conclusion that "free competition is a sufficient condition to ensure maximization of production", Wicksell consistently suggested the elimination of every obstacle to the free movement of wages on the labour market. If, as a result of the discovery of new methods, wages should fall, but are prevented from so doing because, for istance, they are already at the subsistence level, it would be better to maintain workers by public charity, but let the wage rate fall until it becomes equal to the marginal product of labour, because only there is the maximization of production assured[33].

[32] K. WICKSELL, *op. cit.*, vol. I, p. 141.

[33] "... it would in fact be more advantageous... to *reduce* wages to the point to which they would tend to fall as a result of free competition, and to add, by charity, enough to bring up their incomes to the necessary minimum; it would be better to do this than to insist that every labourer employed should earn the subsistence wage" (*ibid.*).

This confidence in the capacity of the labour market to reach an equilibrium point lies in the possibility that a wage fall is coupled with the adoption of higher labour-intensive methods and a lower average productivity of labour. This possibility exists in the simple case previously discussed where only one commodity is produced by itself and labour. Wicksell is convinced that such a possibility exists even in the more general case where means of production other than the commodity produced are employed. Indeed, introducing his theory of capital Wicksell says: "The appearance of capital in the field of production introduces... certain modifications in our conclusions, without, however, rendering them invalid as a whole"[34]. We shall see, on the contrary, that complications arising from the adoption of means other than the commodity produced, compels us to abandon the theory of the labour market based on the demand and supply of such a factor.

If we drop the assumption that only one commodity is produced (or that the capital-labour ratio is the same in the whole economy and commodities are exchanged according to the quantities of labour embodied in them) it is no longer true, generally speaking, that the methods of production can be ranked in such a way that when wages go down a lower average-product-per-worker method becomes more profitable. Let us suppose that three new methods are discovered and that their *WR* relation may be represented as follows:

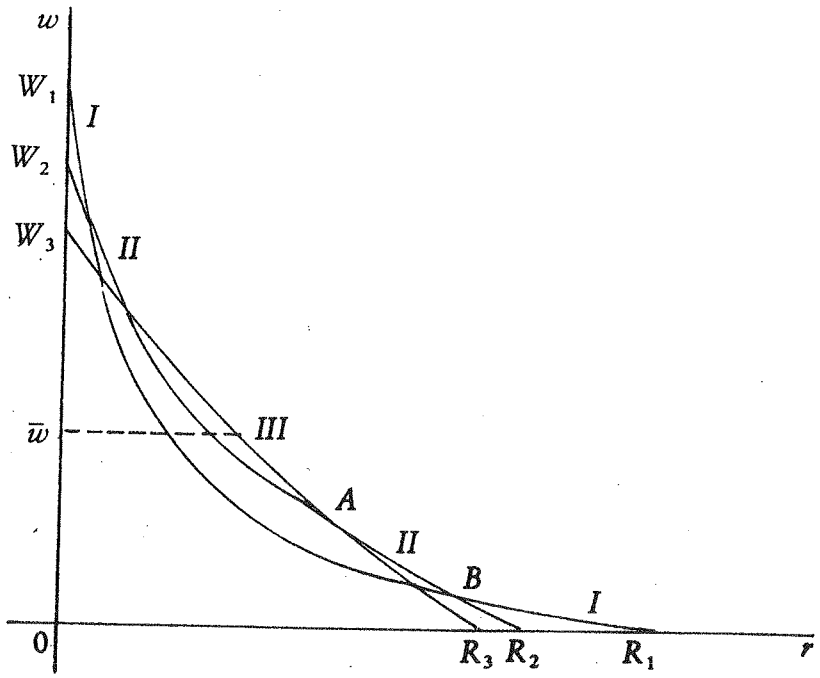


Fig. 9

[34] *Ibid.*, p. 144.

The convexity of these relations shows that

$$\frac{B_a}{L_a} > \frac{B_b}{L_b},$$

i. e., the ratio between the physical quantity of capital and labour is higher in the industry producing commodity "a" than in industry "b". A rise in the rate of profit and a fall in the wage rate therefore do not leave an unchanged price p_b; since the "capital" intensity is lower in the industry producing "b", the change in the cost of this factor will lower the cost of "b" in relation to the cost of "a". The convexity (or concavity) of the wage-profit relationship gives rise to the possibility of their multi-intersection.

Now, let us suppose that at wage rate $\bar{w}$ a method (not represented in Fig. 9) is adopted with an average productivity lower than average productivity q_3 (equal to OW_3) for method III and that all workers are employed. When the three new methods are discovered, the third one, at that wage rate, becomes more profitable and some workers will be dismissed. The pressure on the labour market will now push wages down until, at point A, the second method becomes more convenient. That method has, however, an average per capita productivity q_2 (equal to OW_2) higher than q_3. The adoption of this method will again shrink employment and increase the pressure on the supply side of the labour market. The wage rate will fall further, but at point B method I becomes profitable, with an average productivity even higher than the previous one ($q_1 > q_2$).

This argument is based on the assumption that effective demand is given. But it can be abandoned without altering our conclusions. As soon as a tendency of the wage rate to fall does occur (and method III, method II and method I are subsequently adopted) we can see that the value of capital per worker (k) does not fall, as the marginalist theory requires, but increases when passing from one method to others. Therefore labour becomes more and more "plentiful" as compared with "capital" and the tendency of the wage rate to fall is reinforced.

This simple example is enough to disprove Wicksell's assumption that it is always possible to find a method ensuring full employment after a suitable reduction in the wage rate. This possibility exists only in the simple economy studied by Wicksell, where the methods are rankable according to their physical productivity. But when that assumption is dropped it is impossible to establish a simple relation between the wage rate and the average product per worker (or value of capital per worker). Therefore, it seems reasonable to conclude that the theory explaining the level of the wage rate on the basis of the demand and supply of labour is not well founded. But if the labour market fails to determine the wage rate

(or, more generally, the distribution of income), a possibility for economic theory to find a way out is to take, as Ricardo does, the wage rate (the distribution of income) as given. So, at a further stage in the analysis, it would become easier to look for a more complex explanation of distribution with the help, if need be, of other social sciences.

10. ALTERNATIVE PARADIGMS IN ECONOMIC THEORY

The arguments presented above help us to appreciate the nature and the importance of the renewed interest in classical economics. The idea that progress in scientific activity is a continuous flow is widely accepted: progress consists in a cumulative construction of increasingly extended knowledge about some fundamental assumption laid down by the "founding fathers". The history of science is nothing but a chronicle and catalogue of the new discoveries which have, from time to time, raised the veil from the "unknown" and improved "knowledge".

This concept of scientific progress affects both physical and social sciences. For instance, the theoretical innovations introduced in economics by the marginalist school in the second half of the last century are often regarded as an improvement on the clumsy economic relationships discovered by classical economists. Schumpeter in his *History of Economic Analysis* says explicitly that "scientific economics does not lack historical continuity. It is in fact our main purpose to describe what may be called the process of the "Filiation of Scientific Ideas"[35] and later on[36] he clarified that progress in economics means the discovery of increasingly perfect analytical tools, that is "better techniques which leave nothing to disagree about".

This conception of the development economic thought does not seem acceptable. T. S. Kuhn[37] has shown how in the history of science rather than of "progress" we should speak of "revolutions". "Normal Science" is nothing but "research firmly based upon one or more past scientific achievements, achievements that some particular scientific community

[35] J. A. SCHUMPETER, *op. cit.*, p. 6.

[36] "... from the earliest times until today, analytic economists have been interested, more or less, in the analysis of the phenomenon that we call competitive price. When the modern student meets the phenomenon on an advanced level of his study, for istance in the books of Hicks or Samuelson, he is introduced to a number of concepts and problems that may seem to him difficult at first, and would certainly have been completely un-understandable to so relatively recent an author as John Stuart Mill. But the student will also discover before long that a new apparatus poses and solves problems for which the older authors could hardly have found answers even if they had been aware of them. This defines in a common-sense and at any rate a perfectly unambiguous manner, in what sense there has been 'scientific progress' between Mill and Samuelson" (*ibid.*, p. 39).

[37] T. S. KUHN, *The Structure of Scientific Revolutions,* Chicago & London, The University of Chicago Press, 1962.

acknowledges for a time as supplying the foundation for its further practice"[38]. The fundamental statements (laws, theorems, etc.) underlying "normal science" are labelled by Kuhn as paradigms. The history of scientific thought has shown that in certain revolutionary periods, normal science enters a crisis owing to the more or less acknowledged impossibility of explaining some new important phenomena using the old set of paradigms. The discovery of a new paradigm, e. g. the Copernican system compared to the Ptolemaic system, is not welcomed at once by the scientific community, as one would expect if the new knowledge were a simple "addition" to the existing stock, but is hotly contested. The introduction of a new paradigm not only means a change in the way scientists look at the world, but also in their *Weltanschauung*[39].

The relative assessment here presented of the marginalist theory compared with the classical theory of value and production should be sufficient to show that the different results of Wicksell's and Ricardo's analysis are not the result of improved analytical tools, but the result of different paradigms used to study the same reality. The functioning of the labour market, i. e. the forces underlying the wage rate, is completely different in the two theories. The same happens for the forces determining the volume of production and employment. While the classical theory of value may be very well coupled with the theory of effective demand, the assumption that the volume of production is given is incompatible with the marginalist notion that labour is paid on the basis of its marginal product and that competition (frictions are excluded) always pushes the labour market towards full employment.

Clearly this incompatibility between the two points of view is not due to faulty reasoning or logical flaws in one of the two theories. On the contrary, it is precisely in the case where only one commodity is produced by means of itself and labour and, therefore, the marginal productivity theory is quite consistent, that the different assumptions on which the notion of a competitive market is based are more clearly highlighted. For this reason, one can easily forecast that the present controversy among economists belonging to different streams of thought cannot be decided on the basis of a simple demonstration of the opponent's inconsistencies. "Like the choice between competing political institutions, that between competing paradigms proves to be a choice between incompatible modes of community life. Because it has that character, the choice is not and cannot be determined merely by the evaluative procedures characteristic

[38] *Ibid.*, p. 10.

[39] *Ibid.*, ch. X. On this subject for instance Kuhn says: "The very ease and rapidity with which astronomers saw new things when looking at old objects with old instruments may make us wish to say that, after Copernicus, astronomers lived in a different world. In any case, their research responded as though that were the case" (p. 116).

of normal science, for these depend in part upon a particular paradigm, and that paradigm is at issue. When paradigms enter, as they must, into a debate about paradigm choice, their role is necessarily circular. Each group uses its own paradigm to argue in that paradigm's defense"[40].

This does not means that the struggle between two alternative paradigms cannot find resolution but it does mean that the outcome depends more on the power of persuasion of a certain scientific community, than on proofs and verifications, as traditionally understood. "Probably the single most prevalent claim advanced by proponents of a new paradigm is that they can solve the problems that have led the old one to a crisis"[41].

In the history of economic thought it seems appropriate to say that the problem which caused a confidence crisis among economists over the marginalist theory (the normal science) was unemployment. Although the marginalist theory of production and distribution was renewed and complicated, during the years of the Great Depression, it more and more clearly revealed its inability to explain the everyday waste of economic resources. For this reason the Keynesian theory of effective demand quite suddenly was accepted by economists as a useful analytical tool. Nevertheless, the Keynesian theory did not replace, because that was explicitly not its aim, all economic theory. As a matter of fact, Keynes agreed on the traditional theory of capital and the rule that real wages are equal to the marginal product of labour. This curious marriage between components of the marginalist theory and elements in contrast with it can at last be abandoned. The modern formulation of the classical theory of value and distribution allows a more satisfactory foundation of Keynesian theory itself; since hopefully a better explanation can be worked out of the notions of firm, industry and other macroeconomic quantities (for instance effective demand).

In this perspective it is understandable the great importance of the debate on the impossibility of finding a decreasing relation between the rate of profit and the "quantity" of capital and therefore on the impossibility of building up a demand curve for the factors of production. Anomalous relations between the value of capital and the rate of profit were already noted by Wicksell and, after the Second World War, numerous instances of this kind of anomaly abounded in economic literature. Nevertheless these phenomena were always considered as "curiosa" or exceptions to the well-established rule stating the opposite. Only after the reformulation of the classical theory of value and distribution was it possible to demonstrate that these "curiosa" could really be explained very well

[40] *Ibid.*, p. 39.
[41] *Ibid.*, p. 152.

and that, therefore, the new theory could rightly claim it had replaced the old one.

The outcome of the conflict however will not depend, as we have already said, only on the logical soundness of the new theory. As Kuhn says "Individual scientists embrace a new paradigm for all sorts or reasons and usually for several at once. Some of these reasons... lie outside the apparent sphere of science entirely"[42]. Therefore, the issue of the present scientific revolution in economic thought will be decided also by the more general debate on the *Weltanschauung* unavoidably connected to the new paradigm.

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[42] *Ibid.*, pp. 151-2.