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A note on capital obsolescence (and underutilization) in classical and neoclassical normal positions

ROBERTO CICCONE*

Abstract: On account of the relevance that in principle the size and composition of the existing stock of capital goods might have, we attempt to verify whether in the classical and neoclassical approach thereotical positions may retain their role as centres of gravity in situations of prolonged divergences between the existing capital stock and the size and/or physical composition of the set of means of production implied in normal magnitudes. The kind of divergence against which we will compare the one and the other theoretical system consists, in particular, in the maintenance in use of 'machines' that have been rendered obsolete by the introduction of some change in the 'dominant' methods of production, i.e. the methods relevant to price determination, but which producers find it convenient to continue operating for the rest of their useful life.

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PREMISE

A fundamental point touched on extensively by Garegnani is the specification of the differences between the classical and the marginalist, or neoclassical, approach, both with regard to the determinants of distribution and prices, and with regard to the analytical structure of one and the other theory (Garegnani [1992] 2017, 2002, 2007a, 2007b). This theme is complemented by a further fundamental element of Garegnani's contribution, consisting of the clarification of the role of 'centres of gravity' attributed to the theoretical variables both in the classical approach and in the 'long-period' versions of neoclassical theory (as distinct from the more recent formulations in terms of temporary and intertemporal general equilibria) (Garegnani 1976).

* Roma Tre University. Email: roberto.ciccone@uniroma3.it

In the present note those elements of Garegnani's work constitute the premise to start from in order to examine the capacity of the theoretical positions determined in the two approaches to face the problem that will be specified in a moment. We will refer, for the classical theory, to the determination of distribution and normal prices in the correct formulation provided by Sraffa, and, for the neoclassical theory, to its 'traditional', or long-period, versions, in which capital is treated as a single quantity expressed in terms of value. For what concerns us here, rather than the formulation of one author in particular we shall refer to the general characteristics of those versions, and will leave aside the well-known difficulties encountered by the notion of capital as adopted in them.[1]

As mentioned a few lines above, Garegnani pointed out that the meaning assigned to the normal, or long-period sets of magnitudes determined in either approach is that of reference positions, namely 'centres of gravity' of the actual positions that the economy may assume over sufficiently lengthy stretches of time. What we want to argue is that, for the theoretical positions elaborated within the classical approach, the capacity to play this role is broader and more general than for those determined by neoclassical theory. By this we mean that the significance of the former extends to concrete circumstances which either neoclassical theory cannot apply to without introducing very special assumptions, or are even inadmissible for theory.

As is implicit in the meaning of central position of effective magnitudes, the 'normality' of the conditions defining the theoretical set of values stands in the face of the divergences from those conditions that moment by moment occur in reality, causing corresponding deviations in actual from theoretical values. The factors determining those divergences are most often conceived as non-persistent, and thus eliminated over sufficient extensions of time – owing to their own temporary nature, or as a result of acts of production and exchange reacting to the divergences themselves. However, we will deal here with specific *long-standing* divergences involving the capital stock, which, on account of their nature, can be conceived not to prevent, and rather coexist with, the gravitation towards the theoretical position.

In both theoretical systems, the determination of distribution and relative price system is formally carried out while taking the physical composition of the capital employed as being adapted to output levels and profitable methods of production. On the other hand, there are concrete circumstances owing to which the existing capital stock may diverge, even with relative persistence, from the size and/or physical composition of the set of means of production implied in normal magnitudes. On account of the relevance

that in principle the size and composition of the existing stock of capital goods might have, in the present discussion we attempt to verify whether in either approach theoretical positions determined by making abstraction from such divergences can coherently include them, without losing generality. Put differently, we ask whether those positions may retain their role as centres of gravity in situations of prolonged discrepancies between existing and 'theoretical' capital stock.

The kind of divergence against which we will compare the one and the other theoretical system consists, in particular, in the maintenance in use of 'machines' that have been rendered obsolete by the introduction of some change in the 'dominant' methods of production, i.e. the methods relevant to price determination, but which producers find it convenient to continue operating for the rest of their useful life. [2] Exclusively within the framework of the classical approach we will also consider a second type of divergence, which would be intrinsically incompatible with the structure and implications of neoclassical theory.

THE CLASSICAL APPROACH: A) PRICE EQUATIONS AND OBSOLETE MACHINES

The set of the means of production appearing in Sraffa's equations are just those required by the given levels of output and the given methods of production. In order to move towards the problem we intend to address we could say that the stock of means of production is there treated as completely endogenous to the given outputs and methods of production, hence 'perfectly adjusted' to both those circumstances.

Nevertheless, it is Sraffa himself who, with a temporary detour, in the paragraph titled 'Quasi-rent' considers the case of '[m]achines of an obsolete type which are still in use … although not currently produced'. Adopting Marshall's expression (though 'in a more restrictive sense'), Sraffa specifies that '[t]he quasi-rent … which is received for those fixed capital items which, having been in active use in the past, have now been superseded but are worth employing for what they can get, is determined precisely in the same way as the rent of land' (Sraffa 1960: p. 78).

Although Sraffa limits himself to a verbal description of the determination of the quasi-rent on the obsolete machine, the close analogy with the rent of land implies that an equation of the following type is added to the system of price equations:

$$A'p_a = L'_a w + (A'_a p_a + B'_a p_b + \cdots + K'_a p_k)(1 + r) + M'_a \delta \qquad (1)$$

where A' represents the quantity of commodity a produced by the method

which employs the superseded machine m' (assumed to have constant efficiency and to be the only type of fixed capital used by that method), δ is the unknown value (in terms of the numeraire) of the quasi-rent received on the quantity M'_a of the machine, and the meaning of the other symbols should be self-evident. More specifically, the above equation ideally parallels the equation relating to the production process of commodity a employing the type of machine m^* currently produced:

$$A^*p_a = L^*_a w + (A^*_a p_a + B^*_a p_b + \cdots + K^*_a p_k)(1+r) + M^*_{0,a} p_{m*} r \frac{(1+r)^n}{(1+r)^n - 1} \qquad [2]$$

Here A^* is the quantity of a produced by the method employing the machine of type m^*, $M^*_{0,a}$ is the quantity required of the machine when new (but, due to the assumption of constant efficiency, the quantity would be the same for any age of it), p_{m*} is the normal price of the machine, namely its value when new, and n is the number of years for which the machine lasts (cf. Sraffa 1960: pp. 64-6). As before, the meaning of the other symbols is obvious.

In relation to our argument, it is important to note that the possible presence of obsolete machines still in use is a circumstance that Sraffa places in the context of the configuration of normal prices of produced commodities – indeed, it is precisely within that price system that he conceives the determination of the quasi-rent obtained on a superseded machine. It is therefore implicit to Sraffa's digression that the gravitation of market prices to normal prices is consistent with the possibility that alongside the methods of production determining normal prices and the general rate of profit, methods that have become less convenient can still be in use, with the associated employment of obsolete machines. It follows that for some (or even all) commodities the total output will be fractionated into a number of equations, one for each type of machine used, as is the case of equations [1] and [2] above for commodity a. A first group of equations, one for each commodity produced, would express the methods of production determining normal prices and the general profit rate – the 'dominant', or 'socially necessary' methods of production, activated at the respective output levels. The remaining group of equations, with their respective fractions of the various outputs, would represent the 'old' methods of production still in use, employing machines possibly obsolete. The quasi-rents yielded by the latter machines are the only unknowns which this group of equations would be specifically called upon to determine.

From a more general perspective the point of the argument I feel is

important to emphasize is the admitted compatibility of the normal pattern of prices with relationships between outputs and inputs actually established in the economy that to some extent differ from those implied by the normal prices themselves – in the case under consideration, the use of obsolete machines and associated methods of production in some shares of sectoral outputs. This shows as in the classical approach the theoretical price configuration, while remaining unchanged in its determination, is applicable to concrete circumstances endowed with relative persistence, such as stocks of fixed capital inherited from the past. Compared to the dependence on the given outputs and methods of production, hence endogeneity, of the set of capital goods appearing in Sraffa's own equations, the 'contamination' we are referring to would find its formal expression in that the stocks of machines present as inputs in the second group of equations, being legacies of past production conditions, would instead be the determinants of the shares of sectoral outputs employing them.

B) NORMAL MAGNITUDES AND UNDERUTILIZATION OF EQUIPMENT

An issue partially analogous to the use of obsolete machines arises regarding possibly persistent lower-than-normal rates of utilization of existing equipment (to which, however, no reference is found in Sraffa). Also in such a case the *actual* output-input relations would diverge from those implied by normal prices, without, however, undermining the role of the latter as central values of market prices. Indeed, it is still to Sraffa's equations, with their sets of capital goods adjusted to the given output levels, that we must go in order to know the values to which relative prices can be assumed to tend, even in this kind of concrete conditions.

As I argued elsewhere, the gravitation to normal relative prices does not require that the levels of outputs are such that existing sectoral capacities are utilized at their normal rates. What is needed is rather that output flows match the levels of 'effectual demand', while the latter can happen to be different from outputs obtainable at the normal rates of utilization of existing equipment. Assuming, as is reasonable, a close relation between capacity and the size of equipment, hence fixed capital, those flow adjustments would be easily realised by appropriate changes in the employment of working capital alone, and thus much faster than changes in the size of fixed capital could do. The following passages from Marx's *Capital* appear meaningful in this respect:

> When there is a hitch in production, when the markets are overstocked,

> and when raw material rises in price, etc., the normal outlay of circulating capital is restricted—once the pattern of fixed capital has been set—by cutting down working time to, say, one half. On the other hand, in times of prosperity, the pattern of the fixed capital given, there is an abnormal expansion of the circulating capital, partly through the extension of working time and partly through its intensification (Marx [1893] 1956, Vol. II, Ch. XV: p. 262);

> an additional expenditure of circulating capital (in materials of production and wages) suffices to enhance the production scale without an expansion of the fixed capital, whose daily time of employment is thus merely lengthened, while its period of turnover is correspondingly shortened (*ibid.*, Ch, XVII: pp. 324-5).

Indeed, variations in the degree of capacity utilization can be seen as the most immediate form taken by capital mobility, particularly for the species of working capital, in response to profit opportunities.

The relevance of changes in utilization rates for the tendency towards normal prices appears even greater if, in accordance with Garegnani's reconstructive proposal to combine the classical explanation of distribution with the Keynesian autonomy of demand (Garegnani 1978 and 1979), we admit the possibility of non-temporary and generalized falls in demand relative to existing capacity. Indeed, in addition to other possible rigidities proper to fixed capital, under those conditions the downsizing of the stocks of equipment relative to demand levels could be long frustrated by the effects of reduction in gross investment on demand itself.

Let us now consider how the under-utilization of equipment bears analytical similarities to the use of obsolete machines. For this purpose, we identify the equipment with machine m, and assume that this constitutes the only type of fixed capital employed in the production of commodity a. In order not to overlap one problem with the other, we also assume constant returns to scale.

The normal price of a, with all other prices being also at their normal values and assuming constant efficiency of the machine, is expressed by an equation analogous to [2] above:

$$p_a = l_a w + (a_a p_a + b_a p_b + \cdots + k_a p_k)(1+r) + m_a[p_m r \frac{(1+r)^n}{(1+r)^n - 1}] \quad [3]$$

where $l_a, a_a, b_a, \ldots, m_a$ represent the coefficients of production of one unit of a.

In the above equation the quantity in square brackets $p_m r \frac{(1+r)^n}{(1+r)^n-1}$

measures the gross return needed to pay for an annual flow of *net* profits at the general rate *r* on the normal price of the machine, plus the replacement of the latter at the end of its life. In the above form the net profit and depreciation charge is expressed with respect to the value of the machine when new, that is p_m, but under the constant efficiency assumption its amount is the same for any age of the machine within the useful life of the latter. Indeed, what changes as the age increases is only how the charge divides between depreciation quota and net profit, with both components referring to the normal value of the machine of the appropriate age. Indicating this normal charge by ρ_n, the charge can thus be more generally expressed by the equality

$$\rho_n = v_{m,s}r + d_s$$

where $v_{m,s}$ and d_s stand, respectively, for the normal values of the machine and the depreciation charge, both referring to the machine aged *s*, with *s* = 0, 1, 2, …, *n*, and the product $v_{m,s}r$ represents the net profit yield at the general rate *r* obtained on the normal value the machine. As the age of the machine increases from age 0, its normal value $v_{m,s}$ decreases from p_m, while the value of d_s increases starting from $d_0 = p_m \frac{r}{(1+r)^n-1}$.[3]

Equation [3] can therefore be rewritten by using the generic expression ρ_n for the normal gross return on the machine:

$$p_a = l_a w + (a_a p_a + b_a p_b + \cdots + k_a p_k)(1 + r) + m_a\, \rho_n \qquad (4)$$

Particularly with regard to the m_a coefficient, it must be specified that, as will be further elaborated below, it implies the *normal* rate of utilization of the machine; in other words, it measures the quantity of machine used, at normal utilization, per unit of product. It follows that at a rate of utilization lower than normal the quantity of machine *actually* employed per unit of output, call it $\overline{m}_a$, would be larger than m_a.

Assuming that a lower-than-normal utilization of the machine does not cause any change in the unit coefficients of the other inputs, at the normal price of *a* (and normal values of wage and other prices), for one unit of output of *a* produced by underutilizing the machine the following equation must hold:

$$p_a = l_a w + (a_a p_a + b_a p_b + \cdots + k_a p_k)(1 + r) + \overline{m}_a \rho \qquad [5]$$

Comparison of equations [4] and [5] obviously entails

$$\overline{m}_a \rho = m_a \rho_n$$

where ρ represents the *actual* gross return on the underutilized machine. And since $\overline{m}_a > m_a$, it evidently follows

$$\rho < \rho_n$$

which implies

$$\rho < v_{m,s}r + d_s \tag{6}$$

The actually realized return ρ turns out lower than the normal gross return needed to pay for net profits at the general rate r and the replacement quota. Lastly, distinguishing in ρ the net profit component, call it σ_s, and the replacement quota reckoned at its normal value d_s, it is

$$\rho = \sigma_s + d_s$$

and inequality [6] can be rewritten as

$$\sigma_s + d_s < v_{m,s}r + d_s$$

from which obviously

$$\sigma_s < v_{m,s}r$$

If, now, profits are commensurate to the normal value of the machine, we get

$$v_{m,s}\bar{r} < v_{m,s}r$$

where $\bar{r}$ represents the profit rate *actually realized* on the value of the machine, evidently lower than the normal rate r:

$$\bar{r} < r$$

However, a generalised overcapacity would not prevent relative prices from tending to their normal values, implying normal capacity utilization and the normal rate of profit. Capital mobility acts through gross investment, which competes, or can compete, with capital already employed in the sector to which the investment is directed. And since the size of new equipment that would be installed in an industry would obviously be appropriate to the production levels that the investor expects to realise, in case displacing other producers, the expected utilization of that equipment would be the normal one—hence the latter is the utilization rate proper to the price resulting from the competitive process, i.e. the normal price.

Divergences in relative prices from normal values would then lead to corresponding sectoral differences in investment returns that would not be affected by sectoral divergences in actual capacity utilization from the respective normal rate. It thus appears that even under the conditions considered, the classical competitive process would be able to push market prices towards the normal configuration, in which the rate of return on gross investment would be uniform and equal to the normal rate of profit.

This also makes it possible to see the relevance of the normal rate of profit, with the implied degree of normal capacity utilization, in the face of widespread underutilization of existing capacity and a corresponding ratio of realised profits to capital stock that is lower than the normal rate of profit. The significance of the latter as a return obtainable more generally on the investment in new equipment, rather than on the existing capital stock with its possible inadequacies, is not new: we find an instance of it in Wicksell (1935, p. 193), where the 'normal or natural real rate [of interest]' is said to correspond to 'the expected yield on the newly created capital'; also in Marshall (1920, VI, ii, 4, p. 443): '"the general rate of interest" applies in strictness only to the anticipated net earnings from new investments of free capital' (see also V, viii, 6, pp. 341-2). And that implication may perhaps even be read in a remark by Sraffa about the adoption of a cheaper method of production:

> At any given level of the general profit rate, the method that produces at a lower price is of course the most profitable… *for a producer who builds a new plant* (Sraffa 1960: p. 81, our italics).

It follows from what has been pointed out so far that the triple: normal relative prices, normal capacity utilization and normal profit rate is *inseparable*, and it is therefore not legitimate to deal with one of these concepts without implying the others. Insufficient awareness therefore seems to be present in certain strands of models in which, in the presence of non-temporary divergences between actual and normal capacity utilization, the latter is supposed to passively adjust to the former, thus losing sight of the connection between normal utilization and at least one of the parameters that enter into normal prices, the unit coefficient of fixed capital. By their very nature those parameters constitute minimal or, more generally, socially necessary quantities, as such not reducible by the pressure of competition: and this clearly cannot apply to what would be increased fixed capital coefficients merely reckoning the occurrence of a fall in output levels relative to the stocks of equipment.

An analogous objection can be raised against the connected idea that the general rate of profit would depend on the actual utilization of capacity, whether or not normal utilization is assumed to adjust to it. Instead, keeping the two notions of capacity utilization appropriately distinct avoids the overlap between a quite ambiguous ratio between realised profits and existing stock of capital (with all the difficulties involved in even conceiving the value of the latter) and the theoretically precise concept of normal rate of profit—which, as specified earlier, is to be more generally conceived as the rate of

return on (gross) investment, hence newly produced capital goods, than on capital as stock.

THE NEOCLASSICAL APPROACH: A) OBSOLESCENCE AND 'QUANTITY OF CAPITAL'

We have seen how classical analysis is able to deal without particular difficulty with a circumstance that in practice can occur in the real economy, such as the presence of obsolete machines. Let us now consider what we can find, as to the same circumstance, in the neoclassical theory, taken in its long-period versions. We will refer to a small sample of authors in whom we have found elements directly or indirectly related to the issue; it is of course possible that other scholars have also made relevant contributions on the subject, which however we have not been able to detect in the preparation of this note. For the neoclassical approach, on the other hand, we exclude a priori the admissibility of persistent and generalized excess capacity, which presupposes an autonomy of demand from productive capacity that is inconsistent with that theory.

One of the data of the traditional versions of neoclassical theory is the available 'quantity of capital', expressed as single magnitude of value. Explicitly or implicitly, the legitimacy for taking that magnitude as given would rely on the one hand on the observable physical set of the several capital goods existing in the economy, with its value taken in turn as known, and on the other on the presumption that changes in the physical quantities of capital goods required by the equilibrium conditions would take place without altering that overall value – i.e., the capital stock would change in 'form' without changing in 'quantity'.

As some of the stock of machines becomes obsolete because of the introduction of new methods of production and equipment, its value could experience an even considerable decrease. A potential conflict then apparently arises between the occurrence of such losses in the existing 'quantity' of capital and the concept and analytical role of capital in the formulations of neoclassical theory we refer to. As we shall see, if in some authors the contrast emerges directly in terms of difficult reconciliation, in others it can be found in the need to arbitrarily take for granted that the conception of capital proper to the theory implies adequate compensation of such losses.

One author who contemplates obsolescence as a cause of reduction in the value of the capital stock is Sidgwick (1883):

> The progress of invention … continuously affords opportunities for fresh

> investments—as in newly invented machinery, &c.—inevitably tending to reduce the value of portions of capital already in existence, to an extent which, as far as we know, may vary indefinitely (p. 165).

On the other hand, the 'paradoxical' character with which Sidgwick qualifies this capital decrease signals its difficult compatibility with the theory:

> Such improvements in industrial processes of course tend to make the community richer … But, generally speaking, they tend also to reduce the value of a certain amount of the capital already invested in instruments of production … . Hence their effects on the wealth of the community … are necessarily mixed; and may be, on the whole, of a negative kind … so that the community would appear to be spending its capital …. This paradox is the inevitable result … of including in one aggregate of wealth, along with things immediately consumable, products that are only useful and valuable as a means of producing the former: but, since most of that part of real incomes which is saved exists normally in the form of … instrumental products, I do not see how we can conveniently adopt any other view of wealth, in discussing Distribution. We must therefore be content to note the possibility of this paradoxical result, and to guard ourselves against being misled by it (p. 375).

And, as proof of the problematic nature the phenomenon presents to his eyes, Sidgwick is lead to reduce its quantitative relevance by arbitrarily adding that '[s]o great a destruction of the existing value of capital as that supposed above is highly improbable'.[4]

The issue is also dealt with in Hobson (1911):

> New savings, taking shape in productive instruments slightly superior to those hitherto in operation, often displace or cancel the latter in a socially wasteful manner. It is of course socially useful that improvements, however slight, shall be utilized without unreasonable delay. But competitive capitalism, in which the profits of individuals determine the pace of change, regardless of the losses of other individuals, involves great net wastes of capital. A proper computation of the social gain of these improvements demands that this premature death of former savings, invested in capital now competitively displaced, shall be taken into account (p. 197); [5]

as well as in Hobson (1913):[6]

> The rapid rate at which in recent years new inventions have been applied in many of the fundamental industries, involving the supply of large quantities of expensive plant and machinery … is another source of great waste. A very little reflection will show that the pace at which improvements are applied in industry, regarded from the standpoint of industry as a whole, is often very wasteful. Under a competitive system in which the

> discoverer of some very slight economy can cancel at once the whole value of the existing plant of all his competitors, there can be no provision against such waste (p. 107).

One can appreciate, in the excerpts above, the contradictory aspect of the obsolescence of some of the existing equipment compared to how capital is conceived by theory. Understood as a 'substance' that is formed first and independently of the physical forms it takes, and whose 'quantity' remains unchanged as those forms change, the concept of capital adopted by the theory does not appear compatible with the reduction in the stock of capital caused by the competition of 'new' savings with the 'old'—a diminution analogous to what would occur if society decided to consume some capital whereas, 'paradoxically', it is instead saving. Ultimately, the contrast seems to lie in that, with the loss of value of machines that have become obsolete, part of the 'substance' embedded in those physical forms would disappear, due to the physical form assumed by the newly-formed 'substance'. This sort of displacement seems inconsistent with the conception of capital adopted by the theory, which rather assumes that capital, once formed, by its very nature must perdure (unless of course it is the community who decides to consume it).

The last argument brings us right to the general quality of 'permanence', or 'perpetuity' which, unlike the views considered so far, is expressly acknowledged to capital by various authors. In Clark (1899) we read:

> The most distinctive fact about what we have termed capital is the fact of permanence. … It is this idea of permanence which originally gave a name to the kind of wealth which is used for productive purposes, for it is a kind of wealth of such capital, or vital, importance that it must always be kept intact (p. 117).

> The point of sharpest contrast between capital and most capital goods is … the permanence of the one, and the perishability of the other (p. 118).

> There is, indeed, no limit to the ultimate power of capital, by changing its form of embodiment, thus to change its place in the group-system of industry (id.).

Similarly, Knight (1934) claims that

> All capital is inherently perpetual. If a particular instrument "wears out", or for any other reason ceases to be "rentable", its replacement by another instrument or other instruments of the same earning power … is to be taken for granted as a technological detail (Knight 1934, p. 264).

And, referring to a 'machine', Knight (1935) maintains that it is

> a "part" of an integrated productive organisation which is not bounded by the scope of "plant" or firm, but extends outwards indefinitely to indeterminate limits. Moreover, the capital structure and every unit in it is typically planned to perpetuate itself … (Knight 1935: p. 83).

Let us then consider how obsolescence has been tentatively reconciled with the latter conception of capital and the property of persistence inherent to it. An instance is provided by Pigou (1935). While explicitly including obsolescence among the causes of capital depletion (cf. Pigou 1935, pp. 235 and 238), in considering the effects of the latter Pigou in turn invokes what he refers to as a 'clear principle', namely

> the concept of capital as an entity capable of maintaining its quantity while altering its form and by its nature always drawn to those forms on which, so to speak, the sun of profit is at the time shining (Pigou 1935: p. 239).[7]

Let us then enter more into the matter. Although conceived as inherent to the nature of capital, the latter's maintenance here referred to cannot but result from the behaviour of agents. With regard to fixed capital, for which obsolescence can occur, the relevant individual decisions are those concerning depreciation allowances. The question that arises is therefore twofold. One aspect concerns the size of the planned allowances, and specifically why such size should be sufficient to keep the capital stock intact even from the potential losses due to obsolescence. A further doubt pertains to the effectiveness of the aggregate of such decisions, each of which would obviously be taken individually, in obtaining what is an overall result.

As to the first interrogative, Pigou offers no more precise indications than the reference to allowances regulated by what he regards as *normal* capital depletion, meant as the depletion 'sufficiently regular to be foreseen, if not in detail, at least in the large', and including 'all ordinary obsolescence' (Pigou 1935: p. 240).[8]

An attempt to explain the motivation behind the maintenance of capital, and thus the size of depreciation allowances, can be found in Hayek (1935). The subject of this essay is precisely the concept of 'constant amount of capital' (Hayek 1935, p. 241), for a large part discussed precisely with reference to Pigou's formulation.[9] Although critical of the notion of quantity of capital as a fund of value, Hayek offers a useful reconstruction of the possible rationale behind the idea of capital maintenance. He wonders

> why, or under what conditions, this aggregate value should remain constant, when conditions change. There can be no doubt that the value

> of at least some of the existing capital goods will be very materially affected by almost any conceivable change. The question then is why should the capitalists, in spite of this change in the value of their concrete capital goods, be able and willing, by an appropriate adjustment of their investment activity, to maintain the total value of their possessions at exactly the same figure as before the change (Hayek 1935: p. 243).

An adequate size of the depreciation allowances being seen as the crucial factor for the maintenance of capital, the passage now quoted mentions the behaviour of capitalists as the agents to whom the decision in the matter belongs. And about the implied motivation for their inducement to keep the capital intact, Hayek argues:

> *ceteris paribus*, a change [in the magnitude of capital] would be a cause of a change in the income to be expected from it, and … in consequence every change in its magnitude may be a symptom for such a change in the really relevant magnitude, income (Hayek 1935: p. 248).

> In the first instance, this reason is that persons who draw an income from capital, want to avoid using up unintentionally parts of the source of this income, which must be preserved if income is to be kept at the present level (*ibid*.: p. 249).[10]

Thus, once obsolescence is included in the factors affecting the useful life of capital items,

> [t[he capitalist who aims at a constant income stream will have to take this into account in deciding the division of his gross receipts between consumption and amortization … [and] put aside amounts proportional, not to the physical wear and tear, but to the decrease in the value of investment (p. 257).

One can note that, although what is at issue is the maintenance of the overall capital stock, in these passages the effects on the latter are made to depend on the depreciation provisions determined by capitalists at the individual level. This brings us back to the second issue we raised earlier, concerning the ability of the set of allowances decided independently by each individual capitalist to keep the *total* capital stock unchanged.

The answer to this question is to be found in the implications of the neoclassical theoretical approach in which the argument is placed. The annual depreciation flows obviously constitute savings out of gross profit, and as such they cannot but be balanced, in their total, by equivalent gross investments. Since in the context of the neoclassical approach the volume of investment is governed by savings decisions, the sum of the individual depreciation decisions determines a corresponding gross investment flow.

This of course does not deny that looking at a single capitalist, his own depreciation allowances and gross investment need *not* coincide; however, the difference between gross savings and investment for one capitalist would be offset by differences of opposite sign for one or more of other capitalists. By making the effects on overall capital dependent on the aggregate of individual depreciation allowances, these authors manifest their implicit confidence in the equilibrating mechanism that would adjust investment to savings decisions.[11]

B) IMPOSING THE 'CAPITAL MAINTENANCE' CONDITION

We can now come back to Pigou's view about the conditions enabling capital maintenance, and in particular the appropriate size of depreciation allowances. [12] Also relying on what is suggested by 'business practice', the adequate allowances would be governed, as we have already hinted at, by

> capital depletion as may fairly be called "normal", and the practical test of normality is that the depletion is sufficiently regular to be foreseen, if not in detail, at least in the large (Pigou 1935: p. 240).[13]

Pigou claims that such depreciation allowances (and thus, for the economy as a whole, corresponding gross investments) would cover 'all ordinary forms of wear and tear ... and all ordinary obsolescence, whether due to technical advance or changes of taste'. Instead, they would leave out 'capital depletion brought about by such things as earthquakes and wars' (*id*.).

The interesting question for our discussion is then that, for the quantity of capital to remain constant, losses in value due to obsolescence of parts of the capital stock should fall within the depletion 'sufficiently regular to be foreseen', and not within the group of circumstances which, not without some forcing, Pigou circumscribes to the realm of 'earthquakes and wars'. Only in the first case would those expected losses contribute to the size of depreciation flows, and thus to the corresponding gross investment, their negative effect on the capital stock being thus offset by the formation of new capital. However, this result would require a correct prediction, by the whole of the agents, of circumstances such as the timing in which the change in dominant techniques would affect the value of equipment in use, the magnitude of these effects, the productive sectors involved: elements that appear difficult to conceive as predictable, all the more so whenever they would be connected to the introduction of technological innovations.

A supplement to Pigou's argument is again offered by Hayek's (1935) interpretive contribution.

While Pigou merely distinguishes between 'normal' depletion, correctly foreseeable, and the one caused by extreme events (wars, earthquakes), hence not foreseeable, Hayek conceives predictability in terms of probabilities assigned by capitalists to circumstances that may affect the value of capital, still allowing in any case for absolutely unforeseeable events. Interestingly, for the first category of circumstances, Hayek in turn believes that a substantially perfect predictability applies, though only for the class of capitalists as a whole. For a change

> the probability of whose occurrence was anticipated, but which does not occur at the moment that was regarded as most probable … deviations of the individual cases from what was regarded as most probable are likely to balance in their effect, so that capitalists as a whole will succeed in keeping their income stream [hence, capital stock] constant (Hayek 1935: p. 262).

Thus, with this presupposed compensation, for the aggregate of capitalists, of the divergences between concrete and expected manifestations of foreseeable events – and thus, it may be inferred, of excesses and inadequacies in individual depreciation allowances – Hayek qualifies the 'normality', and thereby the predictability of the quantitative effects of the circumstances considered foreseeable, in a more articulate (tough still arbitrary) manner than Pigou. For circumstances impossible to predict Hayek admits that 'there is no reason to expect that gains and losses will balance'. Broadening the scope of such events from the delimitation to 'wars and earthquakes' we find in Pigou, Hayek includes in them the case of an 'invention', the kind of changes 'in many ways the most interesting'. And he is explicit that, on account of the 'possibility of a loss of capital invested in plant that is made obsolete', this type of phenomenon 'is much more likely to lead to considerable capital losses than to capital gains' (*id*.).

It remains, nevertheless, that what for Hayek can prevent the full maintenance of capital is exclusively the incomplete forecasting capacity of capitalists, moreover limited, for the aggregate of these agents, to absolutely unpredictable events. And confirming the relatively small weight he thus attributes to that imperfection, Hayek goes so far as to state that

> an approximately correct anticipation of the majority of "changes" … is an indispensable condition of that degree of progress which is observed in actual life … [without which] [e]very change would mean an enormous loss … (Hayek 1935: pp. 265-6).[14]

Indeed, in Hayek's view, predictive capacity plays such a fundamental role in the maintenance of capital as to make him claim that

> the degree to which [capital] can be maintained in a changing world, will depend on the foresight of the entrepreneurs and capitalists … the amount of capital available at any moment in a dynamic society depends much more on the degree of foresight of the entrepreneurs than on current saving or on "time preference" … As an enumeration of individual capital goods existing at the beginning, the "stock of capital" is of course an important datum, but the form in which this capital will still exist some time afterwards, and how much of it will still exist, depends mainly on the foresight of entrepreneurs and capitalists (*ibid.*: p. 266).[15]

In conclusion, against potential losses in value due to obsolescence, both Pigou and Hayek oppose the fulfillment of the condition of capital maintenance by assuming an however appropriate size of specific allowances, and thus a high capacity of 'capitalists' to foresee the phenomenon in the characteristics with which it will occur and the effects it will produce. This urge can be interpreted as reflecting the analytical need to include the existing quantity of capital among the data of the theory. As has been previously observed, conceiving that magnitude as a given rests on the observable set of capital goods, with the total value of the set taken in turn as knowable and invariant with respect to changes in its physical composition. It is then conceivable that this premise is perceived to be in conflict with the reduction of that quantity that would be brought about not by 'wars and earthquakes', but by the rational pursuit of individual interest – such as the competitive introduction of innovations – and thus by behaviour of the same nature as that assumed by the theory in all its spheres. Indeed, as previously observed, the alleged invariance of the quantity of 'substance' constituting capital with respect to the forms it can take would be contradicted by the destruction of part of it due precisely to the forms taken by newly formed substance.

It should be noted that, even granting that the size of the depreciation allowances is adequate to fulfil the condition of capital maintenance, a general problem seems to arise for the theory from the possibility that allowances for depreciation and replacements would, *a priori*, follow different time profiles. Since the question, although relevant, is lateral to the subject of this note, its consideration is deferred to the Appendix.

CONCLUDING REMARKS

Our discussion leads us to conclude that the presence of obsolete machines in the capital stock is a circumstance to which neoclassical theory can apply its normal value system with difficulties that it only copes with by means of largely *ad hoc* assumptions.

A need similar to the one just mentioned has not instead arisen for the

classical approach, within which the existence of obsolete machinery, as well as underutilized equipment, appear as circumstances in respect of which the set of normal values retains its meaningfulness without having to overcome special obstacles. This diversity of results can be viewed as an aspect of the greater flexibility that the classical framework exhibits compared to neoclassical theory, due to their analytical differences.

As already remarked, implicit in the long-period versions of neoclassical theory is a correspondence between the notion of capital that enters as a datum in the supply and demand framework, and the set of existing capital goods, taken in its value magnitude. The necessary maintenance of this link precludes that the value of existing capital may diverge from the quantity of capital relevant for the determination of normal values, and this accounts for the introduction, in the sample of authors considered, of the special assumptions useful to neutralize the potential effects of obsolescence. Ultimately, the inability to deal in more general terms with a concrete phenomenon such as the obsolescence of existing capital is traceable to the overall rigidity of the interrelations that in theory link distribution and prices to outputs and quantities of factors employed – where the latter include, as equilibrium requires, the stock of existing capital.

In the classical approach, the explanation of distribution, based on circumstances quite different from the equilibria of factor supply and demand, does not imply general and univocal relations between the determination of prices and distribution and that of outputs and resource utilization. Referring to the present discussion, the flexibility which the classical approach derives from that characteristic of its analytical structure allows the value system determined by the theory to be relevant even under factual conditions of divergence of the existing stock of capital from the set implied by the normal value configuration – such as, as we have seen, the obsolescence of part of the capital employed or a generalized under-utilization of equipment. This ability of application appears to be an element of superiority compared to the neoclassical approach. As we have seen, in the latter the structure that determines the theoretical value system does not tolerate reductions from obsolescence in the value of existing capital, and this instance of capital depletion cannot be handled without imposing special clauses that safeguard the 'maintenance of capital'. The theory thus comes to be appropriately forged on the concrete phenomenon, reversing the relationship that should exist between the general character of the former and the specificity of the latter.

APPENDIX

On time profiles of depreciation allowances and replacements

If the ages of equipment were not evenly distributed, as is instead often assumed on a more abstract level, the renewals would be quantitatively concentrated in certain periods, and on the other hand there would be periods with low replacement volumes. Instead gross savings flows, including the accumulation of depreciation funds by firms, would in general be distributed over time with a more regular, and in any case different, profile. It follows that gross savings would potentially be in excess of investments in certain periods, and conversely insufficient in periods of concentrated renewals. Remaining within the neoclassical theoretical approach these potential imbalances should be eliminated by changes in the price system, and in particular in the interest rate, with output staying at full employment level. It would then happen that in the former set of periods interest rate reductions would take over the task of raising gross investment to the level of gross (full employment) saving, hence above the volume of renewals: gross investment would therefore contain a share of net investment, resulting in an increase of the capital stock. At the opposite, in periods when the potential surplus of investment over gross saving would be eliminated by increases in the interest rate, investment would fall below renewals, with consequent reduction of the capital stock. The constancy of the capital stock would therefore only be satisfied 'ultimately', and not period by period.

That it is that kind of mechanism that would ultimately keep the capital stock invariant, however, seems difficult to accept even within the traditional theory itself. The action of the rate of interest on investment involves forces that are fundamental to the theory, most importantly the order of convenience of more or less capital intensive methods of production. In the process as described above those forces would be activated, and in periodically alternate directions, by a circumstance of a wholly accidental character, such as the age distribution of the stock of fixed capital which happens to be in existence.

An indication that authors with neoclassical orientation perceive this potential difficulty and attempt to keep it somewhat under control can, for instance, be found in this passage by Haberler:

> For the individual firm, the setting aside of amortisation quotas out of total receipts and their expenditure for replacement of outworn equipment do not always coincide in time. Amortization will usually – though not necessarily – be a continuous process, whereas the replacement of durable means of production is usually discontinuous. For the economy as a

> whole, both processes are more continuous and run parallel. During any period of time, a number of firms use their amortisation quotas to accumulate balances or to repay loans, thus adding to the supply of investible funds in the market, while others draw on their balances or borrow from the market in order to replace their equipment (Haberler 1958: p. 295, our italics).

Somewhat similarly Pigou, in the face of the possibility

> that certain sorts of capital affected by physical change or by obsolescence are discarded, not gradually in parts but suddenly as wholes

takes care to maintain that

> this does not imply that the aggregate of all sorts of capital together must experience a discontinuous discarding (Pigou 1935: p. 238).[16]

The role of the supposed 'parallel run' of the aggregates of depreciation provisions and replacement investments, taken for granted by Haberler and, in some way, by Pigou, seems to be precisely that of ensuring an *ex ante* correspondence between the two processes, so as to avoid the undesirable consequences we mentioned earlier. It seems hardly necessary to say that there can be no reason why that should be the case. On the contrary, the complex set of conditions to be met, first of all the maintenance over time of a sufficiently even age distribution of fixed capital in the whole economy, suggests it would be the exception rather than the rule.

Notes

1. The reason why those are the versions of the theory considered here is that their comparison with the classical approach is more straightforward, the nature of the variables involved being in both that of normal, or long-period values. The same is not true of the variables of modern neo-Walrasian equilibria, the nature of which is more difficult to decipher.
2. The nature of this kind of discrepancy in the existing capital stock with respect to the full adjustment implicit in normal values is different from that of imbalances in the sectoral composition of total capital. While surpluses and shortages of capital in different sectors signal 'errors' in previous investment flows that the mobility of capital tends to correct, the maintenance in use of equipment that has become obsolete is the result of a choice induced by a profitability criterion. Hence also the relative persistence that can mark this phenomenon.
3. The expressions for $v_{m,s}$ and d_s are, respectively, $v_{m,s} = p_m \frac{(1+r)^n-(1+r)^s}{(1+r)^n-1}$ and $d_s = v_{m,s} \frac{r}{(1+r)^{n-s}-1}$, $s = 0, 1, 2, \ldots n$.

4. Cf. also *ibid.*, p. 175.
5. Pigou (1932: p. 161) disputes Hobson's claim just quoted in the text that the social gain of innovations should be netted of the losses due to the capital obsolescence they cause. The argument used by Pigou is not relevant here. The most interesting point in Hobson's reply (1913: p. 108) is the restatement that, under competitive conditions, innovations are not restrained by possible losses due to obsolescence, for, as remarked in both passages from Hobson quoted in the text, in such market set-up gains and losses are in charge of different individuals.
6. Including Hobson in the neoclassical camp deserves however brief an account, in view of the fact that this author is often regarded as a heterodox (or 'heretical') economist, he himself considering himself as such. If we look at the explanation of distribution in his work, we find that it is based on supply and demand forces of the three 'factors of production' land, labour and capital, as is typical of the neoclassical approach (Hobson 1900: pp. 302-4; 1938: pp. 46-7). And in fact his critical stance towards the orthodox theory of distribution does not concern the circumstances that the latter assumes as determinants, addressing, more narrowly, only certain conditions that the theory postulates in its most abstract formulation (Hobson 1914: pp. 173-4) and the effects resulting from replacing them with more realistic assumptions — not unlike what even an orthodox economist might reasonably do.
7. This same passage from Pigou is quoted by Hayek (1935: p. 243, n. 2) to be representative of the conception of capital as a fund variable in forms while remaining unchanged in its aggregate value.
8. Interestingly, in the authors considered here, the causes of capital stock obsolescence referred to consist of exogenous circumstances such as technical innovations (Pigou also mentions changes in consumer tastes: Pigou, 1935: p. 240). The depreciation of part of the capital stock could, however, be brought about by endogenous changes in the 'dominant' methods of production induced by changes in the interest rate (and in general distribution), in turn resulting from net saving decisions of the community – with unchanged technical knowledge and tastes. A conjecture as to the reason for ignoring this circumstance is that the long-period equilibrium was often identified with a condition of stationarity, in which net savings are zero (cf., in this respect, Hayek, 1935: pp. 241-2).
9. Hayek is mainly concerned with Pigou's Economics of Welfare (1932) and only sporadically refers to Pigou (1935). One criticism he makes of Pigou (1932) is the failure to consider obsolescence among the causes of depletion, an objection which however does not apply to Pigou (1935). The acknowledgment of that kind of capital depreciation in the latter work by Pigou is the reason why we only refer to it in the present context.
10. In the article referred to, Hayek's position is often wavering. Even on the point now under consideration, although the main thrust of his argument appears to be that emerging from the passages quoted, we find the oscillation

'[a]lthough we have certainly no right to assume that every person will normally aim at a permanent constant stream of income from his capital, there is probably some justification for regarding this case as one of special interest' (Hayek 1935: p. 249).

11. In a non-neoclassical theoretical framework, with gross investment determined independently of saving decisions, the total of actually accumulated depreciation allowances could turn out to be less than the sum of the planned allowances, since part of the former decisions could be nullified by the failure to realize the corresponding gross profits. This would be the result if the allowance decisions exceeded, in total, the gross investment decisions, as an instance of the general possibility of savings decisions exceeding planned investment, with consequent reduction in the former caused by the contraction of the overall level of output.
12. Pigou's stated aim in the article we are referring to is to define net income, a notion that requires establishing what capital depletion is to be subtracted from gross product. However, this cannot prevent Pigou from referring to the behaviour of agents, thereby introducing a theoretical-descriptive content. The need to reconcile 'economic principle and business practice' (Pigou 1935: pp. 235 and 240), the reference to 'the most productive use for the resources engaged to offset the depletion of capital' (p. 239), which is followed by the passage on the same page quoted above in the text, the notion of 'normal' capital depletion, where normality consists in sufficient regularity, and therefore predictability, are all manifestations of the need for the author to relate to agents' behaviour the circumstances to be considered relevant, in order to avoid the arbitrariness of the criteria adopted in the specification of capital depletion (cf. p. 240). In turn, Hayek (1935), who largely discusses the concept of 'maintenance of capital' in Pigou, as has been pointed out in the text explicitly links the issue to the 'normal behaviour of entrepreneurs' that should produce such maintenance.
13. The passage is also quoted in Keynes (1936, Ch. 4: p. 38), in relation to the issue, also central to Pigou's article, of determining the share of gross investment to be allocated to replacement (and, therefore, the residual portion to be included in the net product). Keynes skeptically concludes that the problem 'presents conundrums which permit, one can confidently say, of no solution' (*ibid*.: p. 39).
14. In the conclusion of the paragraph Hayek acknowledges '[h]ow rich, on the other hand, should we now be if all past changes had been correctly foreseen from the beginning of things!' But on the whole the passage is clearly oriented towards emphasising the relevant predictive capacity present in the system, as would be witnessed by the degree of progress actually observable.
15. Although Hayek disputes the notion of capital as an entity distinct from the complex of physical elements of which it consists, here, as elsewhere in the article, his language actually appears compatible with that conception.
16. Robertson, even more confidently, goes so far as to believe that the matching

of depreciation provisions and replacements would even occur at the level of the single firm: namely, Now to complete the picture we have to consider the waiting done not by individuals off their own bat but by corporate bodies purporting to act on their account. Of this the most important element in western societies is that done by directors of joint-stock companies on behalf of their shareholders. So far indeed as the provision of funds for the replacement of capital goes, it may be taken as the normal thing that this should be done automatically by the company concerned …; the demand for and supply of the waiting, or more strictly the non-dis-waiting, involved just balancing out namely, (Robertson 1958: p. 75).

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