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ON THE THEORY OF AGGREGATE INVESTMENT AS A FUNCTION OF THE RATE INTEREST

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ON AGGREGATE INVESTMENT AS A FUNCTION OF THE INTEREST RATE

Introduction.

§1.

The majority consensus in current macroeconomics([1]) is that aggregate investment is a decreasing function of the rate of interest, and that the elasticity of this function is significant enough to allow one to conclude that, at least on an average over the cycle, in the absence of rigidities the rate of interest is capable of acting as the price bringing investment into equality with full-employment savings (or with natural-rate-of-unemployment savings). This view of the determinants of investment is what lies behind the thesis that, at least on an average over the cycle, a market economy is capable of realizing the full employment of resources, and that long-run growth is therefore determined by the investment of full-employment savings - the view which, after the Keynesian interlude, is again dominating the macroeconomics textbooks.

It is a well-known fact that the *empirical* support for such a view of aggregate investment is weak. The empirical studies of the 1950s and 1960s on the determinants of aggregate investment concluded that it was difficult to ascertain a significant negative elasticity of aggregate investment with respect to the rate of interest, and that the influence of demand and of its variations was anyway much more important (cf. Junankar, 1972, for a survey). These results have not been disproved by later empirical research. The recent survey of investment theory in the *Journal of Economic Literature* concludes:

> "While there is clearly no uniformity in the results and the role of shocks remains to be assessed, it appears to this author that, on balance, the response of investment to price variables tends to be small and unimportant relative to quantity variables." (Chirinko, 1993, p. 1906; also see *ibid*., pp. 1881, 1883, 1897, 1899)

Thus the empirical evidence would appear to suggest that the negative influence of the rate of interest on aggregate investment, if it exists at all, is too weak to justify the belief that investment adjusts to savings faster than does savings to investment via the Keynesian mechanism of variations of aggregate income.

[1]. As represented e.g. by advanced and intermediate textbooks such as those by Blanchard and Fischer, Azariadis, Cuthbertson and Taylor, Leslie, Chrystal, Mankiw, Abel and Bernanke, Barro, Sachs and Larrain, etc.

Therefore, it would seem that it is rather the (non-linear) accelerator, and hence multiplier-accelerator interactions with their potential instabilities, which on the basis of the empirical evidence ought to figure very prominently in the macroeconomics we apply and in the macroeconomics we introduce our students to. The view that economies tend to the full employment of resources, and that long-run growth is with sufficient approximation determined by the investment of full-employment savings, appears then highly doubtful. Which is a conclusion certainly not *prima facie* contradicted by the behaviour of the industrialised nations' economies in the 1930s or in the last two decades.

The present paper argues that the *theoretical* support for the dominant view of aggregate investment as a decreasing function of the interest rate is even weaker, both in its traditional forms and in the more recent ones. The difficulties which have been found in empirically confirming that view of investment are therefore not surprising: there are, it will be argued, no convincing theoretical reasons why a regular negative correlation between investment and the interest rate should be observed.

The paper consists of two parts.

Part I surveys the implications, of the recent capital theory results and connected theoretical debates, for the theory of investment. Its purpose is to make it clear that the traditional view of investment as negatively elastic with respect to the rate of interest was a manifestation of the traditional marginalist conception of capital as a single factor of variable 'form', and that for this reason the results of the Cambridge debates on capital theory (results confirmed by more recent contributions such as the one by Mas-Colell (1989)), which have shown that that conception of capital has no legitimacy, also undermine the traditional view of investment; to this end, it starts by pointing out the reasons for the reliance of pre-Keynesian marginalist (or neo-classical) economic theory on a conception of capital as a single factor, distinguishing it from the use of aggregate production functions; it goes on to argue that neo-Walrasian general equilibrium theories, owing to their problematical connection with the behaviour of real economies, cannot be an alternative foundation for that view of investment, nor for the faith in the tendency to full employment, and that therefore to this day neoclassical macroeconomics relies on the traditional conception of capital as a single factor: this is illustrated with reference not only to the investment function but also to the labour demand function([2]).

[2]. Part I makes no claim to novelty except expositionally; its arguments are in essence the same as those advanced by Garegnani (1976, 1978-9, 1990), Petri (1986, 1991, 1993, 1997) and others (cf. e.g. Eatwell and Milgate, 1983); unfortunately those arguments are still not widely understood and therefore it has seemed useful to synthesise them, in order to make the contents of Part II more readily understandable. I thank here Massimo De Francesco for his comments and MURST and CNR for financial support.

Part II asks whether the view of investment as a decreasing function of the rate of interest can be based on the more recent developments in the theory of investment (Jorgenson's theory, adjustment costs, and Tobin's *q*). The answer is negative, because these theories either illegitimately assume that the returns from investment projects are independent of the rate of interest, or implicitly rely on the traditional view of capital as a single factor.

The conclusion is that there is no theoretical foundation for the view of aggregate investment as a regularly decreasing function of the rate of interest. So economic theory converges with the empirical evidence in suggesting that market economies have no in-built tendency to the full employment of resources, and that we should teach, and apply, a quite different macroeconomics from the one currently dominating textbooks.

PART 1: ***Capital theory, investment theory, and the microfoundations of macroeconomics.***

§2.

This Part discusses the connection between the notion of an aggregate investment schedule negatively elastic with respect to the rate of interest, and the traditional marginalist conception of 'capital'-labour substitution, where 'capital' is conceived as a single factor, embodied in the heterogeneous capital goods, and capable of changing 'form' without changing in 'quantity'.

This conception of capital, which underlies the generality of present-day mainstream macroeconomic models, is nowadays usually claimed to be only a simplifying assumption, the same results being also obtainable - it is more or less explicitly postulated - from the rigorous, fully disaggregated general equilibrium versions of neoclassical theory. It will be useful first of all to explain why this claim is mistaken (the connection between this issue and investment theory will be made clear in the last paragraphs of this Part).

To this end, it is important to be clear on the presence, in the history and in the current state of marginalist, or neoclassical, theory, of two traditions (Garegnani, 1976; Panico and Petri, 1987): 1) a tradition based on long-period general equilibria where the endowments of the several capital goods are unknowns, determined endogenously, and the total capital endowment is measured by *a single number* because capital is conceived of as a single factor 'embodied' in the several capital goods and given in quantity but not in 'form' (i.e. composition), and 2) a more recent

tradition which I call neo-Walrasian, whose intertemporal or temporary general equilibria take as given the *vector* of endowments of the several capital goods.

Authors like Marshall, Jevons, J. B. Clark, Böhm-Bawerk, Wicksell, Robertson, Pigou etc. agreed with earlier, classical authors on the central role, in the theory- of value, distribution, and employment, of *long-period prices,* i.e. of the prices associated with a uniform rate of return on supply price: the prices called natural prices by Smith and Ricardo, long-period normal values by Marshall, and simply equilibrium prices by Wicksell. They thought that economic theory cannot hope to be able to determine the details of disequilibrium, influenced as these are by accidental and by transitory circumstances. What, according to them, economic theory can hope to determine is the average or central values toward which competition causes relative prices, and quantities, to gravitate. But this gravitation *takes time,* during which time production and consumption go on; so *the data determining these centres of gravitation cannot include the amounts in existence of the several capital goods,* because these amounts can and will be quickly altered unless they all yield the same rate of return on supply price. Thus in the founders of the marginalist approach to value and distribution the admission that adjustments take time went hand in hand with the conception of general equilibrium as a situation in which the *composition* of capital - the proportions between the amounts in existence of the several capital goods - was *endogenously* determined. The way to determine it endogenously was, of course, by assuming a uniform rate of return on supply price. (On this aspect there is no difference between these marginalist authors, and the older classical economists whose theory has been recuperated and improved by Sraffa (1960). Thus Wicksell's or Walras's([3]) equilibrium prices, if the assumptions about the type of technology are the same - e.g. circulating capital goods -, satisfy *exactly the same* price equations as Sraffa's modem reformulation of Ricardo's or Marx's natural prices or prices of production([4]).)

[3]. Walras was the only one, among the founders of marginalist theory, to take the endowments of the several capital goods as given, without initially realizing that his conception of equilibrium, which was the usual one of a centre of gravitation of time-consuming adjustment processes (the 'tâtonnement' was described in the early editions of Walras's treatise as including the actual implementation of disequilibrium production decisions) and accordingly comprised the standard condition of a uniform rate of return on supply price, was incompatible with the inclusion of given endowments of the several capital goods among the equilibrium's data. He only realized it some time between the third and fourth edition of his *Eléments d'Économie Politique Pure.* It is only in the fourth edition that he introduces the provisional 'tickets' or *bons* in the tâtonnement, which is now imagined as going on in a situation of suspended economic activity; in that same edition he admits that the given vector of capital endowments will make it impossible to satisfy the condition of uniform rate of return on supply price (cf. Garegnani, 1990).

[4] . And, just as in the classical authors, so also in Walras and in Wicksell the slow changes that long-period prices may be undergoing over time in spite of the endogenous determination of

But the *uniformity* of the rate of return on supply price only imposes that the economy be on the so-called wage curve (also revealingly called by neoclassical economists the factor-price frontier([5])), it does not select the point on that curve: for that, one needs that the *level* of the rate of return on supply price, i.e. the level of the rate of interest, be also determined. The conception of 'capital' as a single factor, a substance of which the changing and passing capital goods are only transitory embodiments, and whose services are rewarded by the rate of interest - the conception which will be indicated in the sequel with 'capital' in inverted commas -, allows the logic of the supply-and-demand approach to distribution to be extended to the rate of interest, while treating the composition of the stock of produced means of production, i.e. the 'form' of the endowment of 'capital', as endogenously determined. For each rate of interest, and for each composition of demand, the assumption of a uniform rate of return on supply price determines the cost-minimizing methods of production - and thus the capital goods desired by firms - simultaneously with relative prices and with the real wage; thus, under the assumption of long-period general equilibrium on product and factor markets (where the endowments of the several capital goods are not given, but are instead endogenously determined as equal to the stocks desired by firms) one can derive the long-period vector of capital goods' endowments necessary for equilibrium as a function of the rate of interest([6]). The remaining degree of freedom is 'closed' through the condition that the vector of capital goods desired by firms must 'embody' the amount of 'capital' of which the economy is endowed. 'Capital', in this view, is destroyed and re-created, and can change its 'form' in the process, much like an amount of water congealed into pieces of ice which gradually melt and evaporate, and are then re-formed by congealing more water: the total

the composition of capital - changes due, e.g., in the marginalist approach, to the slow change of distribution over time if the growth rate of labour supply is different from the growth rate of capital - are neglected in the determination of equilibrium (i.e. the equations *of* equilibrium are formulated as if relative prices were constant over time), precisely because of their slowness.

[5] . Cf. (Garegnani (1970) The term 'factor-price frontier' for the curve connecting the rate of wages to the rate of interest (or of profits) pre-supposes that the rate of interest is the price of a single factor, i.e. the price of 'capital'. This is precisely what is in question, so the term should be avoided.

[6] .This derivation is easiest if it is assumed that the economy is stationary (no net savings whatever the prices), but it can easily be extended to non-stationary economies, under some assumption as to the composition of net investment, cf. Petri (1997). The general equilibrium character of the analysis shows that aggregate production functions, at the industry or economy level, were not in the least the characteristic element of this tradition, the motivation for the conception of 'capital' as a single factor was not the *convenience* of aggregation, it was the *need* to leave the composition of capital as endogenously determined. The legitimacy of the assumption of constant relative prices, which has been questioned by some authors (e.g. Howard and King, 1992, p. 301) on the basis of the so-called 'Hahn problem' (Hahn, 1987), is defended in Petri (1997).

amount of ice can change its 'form' without changing in 'quantity' (here weight), if the newly-congealed water is equal in amount to the water lost through melting and evaporation, but is congealed into ice shapes different from the melting ones. The process through which the change in the form of 'capital' was thought to operate was, of course, the utilization of the resources, which might have produced the capital goods necessary to replace the worn-out capital goods, for the production of different capital goods([7]). Thus the 'form' of 'capital' was thought to adapt itself to the one desired by firms, and equilibrium only required that the total amount of 'capital' demanded by firms be equal to its endowment.

Obviously the conception of 'capital' as a factor of production entailed that the average economy-wide 'capital'/labour ratio was thought to be a decreasing function of the ratio between the rate of interest and the rate of wages, what made it possible to view the rate of interest as the price bringing the demand for 'capital' into equality with its given endowment.

§3.

The conception of equilibrium as a situation where there is a uniform rate of return on supply price also explains why all the authors, who adhered to that conception of equilibrium and hence adopted the notion of'capital' as a single factor, measured the endowment of 'capital' as an amount of *value* There was a logical necessity behind such a measurement. In equilibrium, different 'chunks' of the same factor must earn rewards proportional to the amount of the factor they contain: e.g. if there are two fields A and B of land of the same quality and if in equilibrium field A earns a total rent twice as big as field B, we know that A's surface must be twice the surface of B. If now A and B are two capital goods, with capital good A earning a net rental twice as big as B; and if we want to see these rentals as earned by the productive contribution of a common factor 'capital' embodied in them; then we must conclude that A contains twice as much 'capital' as B; but, in a uniform-rate-of-return-on-supply-price situation, capital good A will also have a cost of production, and a

[7] . The legitimacy of the assumption that one may abstract from net accumulation while allowing the 'form' of 'capital' to change rested on the fact that the speed, with which an economy can alter the relative proportions between the amounts in existence of the several capital goods, could be presumed to be generally much greater than the speed with which the total stock of 'capital' was altered by net accumulation: this made the treatment, of the endowment of 'capital' as given, as legitimate as the analogous treatment of the endowment of labour (which is also generally not strictly constant, being altered e.g. by population growth), when determining long-period prices and quantities. So (cf. Garegnani, 1976) no assumption of stationariness nor of steady growth was implied by the notion of long-period equilibrium, which should not therefore be confused with the notion of *secular* equilibrium in which the accumulation of capital has come to a halt.

value, twice as great as B. So necessarily the equilibrium relative values of different capital goods must be a measure of the relative amounts of 'capital' embodied in them. If relative prices do not change, then it suffices to measure 'capital' in units such that a capital good of unitary value embodies one unit of 'capital', and then the value of capital goods will also measure the endowment of 'capital' and its variations.

Thus 'capital' comes out to be homogeneous with income (and with savings, which in fact maintain and increase capital). This fact may have made it easier for some applied neoclassical economists to consider it legitimate to represent economies via aggregate production functions Y=F(K,L); but the use of aggregate production functions must be seen as only an attempt at simplification of a theory which was in fact a disaggregated, general equilibrium theory. Thus e.g. Wicksell (1935) formulates a completely disaggregated system of general equilibrium, and needs nonetheless the conception of'capital' as a single factor, whose given endowment is measured in terms of value, because he treats the *composition* of the capital endowment as determined endogenously by the tendency toward equilibrium (which is a long-period equilibrium).

§4.

Let us now point out a grave inconsistency of such a conception of capital: any change in distribution, by altering the relative values of commodities, will alter the relative amounts of 'capital' contained in different capital goods (or in heterogeneous bundles of capital goods); thus the notion of an unchanging 'quantity of capital' across changes in 'form' is impossible to define independently of relative prices and of the choice of numéraire. It is therefore impossible to take the endowment of 'capital' of an economy as given in terms of a single number without arbitrariness. For instance, let us assume that there are only two types of capital goods, A and B, and that in the economy whose long-period equilibrium one wants to determine, at the time one collects the data necessary to determine the equilibrium, these capital goods have the same value and yield the same rate of return on their supply price, and there are 10 units of A and 10 units of B: if 'capital' is measured in units such that one unit of A embodies one unit of 'capital', then the 'capital' endowment of the economy is 20 units. In this economy there is - let us assume - labour unemployment, and one wants to determine the full-employment long-period equilibrium to which presumably the economy will tend. Let us suppose one collects enough data as to build a numerically specified long-period general-equilibrium model, and one determines the equilibrium on the basis of the observed data, including the capital endowment (measured as a single number). The calculated equilibrium, let us assume, indicates that the equilibrium composition of capital is 8 units of A and 24 units of B, which is the same

quantity of 'capital' as in the observed economy because - let us assume - in equilibrium the capital good B has half the value of A, and the quantity of 'capital' contained in one unit of A had been chosen as the unit of measurement of 'capital' (analytically, this is equivalent to choosing good A as numéraire and measuring 'capital' as an amount of value). But had a different unit of measurement of 'capital' been chosen, 8 units of A and 24 of B would *not* have represented the same 'quantity of capital' as the 10 units of A and 10 of B of the original situation: for instance, if it were decided that it is one unit of B which contains one unit of 'capital', then 8 units of A and 24 of B at the new relative prices would represent twice as much 'capital' as in the original situation; and had it been decided that it was the original vector (10A, 10B) to contain 1 unit of 'capital', then at the new relative prices 8 units of A and 24 of B would embody 1.33 units of 'capital'. Thus, for each different numéraire, one would obtain a different equilibrium because the set of vectors (A,B) representing the same quantity of 'capital' as in the original situation would be different. Also, unless one chose as numéraire precisely the vector of capital goods existing in the observed economy, assessing whether the quantity of 'capital' had changed or not would also depend on the relative prices of capital goods one started from: if, in the above example, in the original situation there were a change in distribution which made good B's value different from the value of A while their physical endowments were still the same, then with A as numéraire the equilibrium considered above would come out *not* to have the same endowment of 'capital' as the original economy. And even choosing as numéraire precisely the vector of capital goods existing in an economy, the arbitrariness in deciding whether two equilibria differing in relative prices have or not the same endowment of 'capital' would not disappear, because it would be arbitrary which one of the two vectors of capital endowments should be chosen as numéraire([8]).

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8 Let (A, B) and (A', B') be the capital endowment vectors in two equilibrium situations, and let (p_A,p_B), ($p_{A'}$,$p_{B'}$) be the capital goods prices in the two equilibria. If one chose the first equilibrium's capital vector as numéraire, the equality of capital endowments would require $A'p_{A'}+B'p_{B'}= Ap_{A'}+Bp_{B'}$. If one chose the second equilibrium's capital vector as numéraire, the condition would be $Ap_A+Bp_B= A'p_A+B'p_B$. Thus if the transition from the first to the second equilibrium leaves the quantity of 'capital' unaltered, the transition back to the original equilibrium would *not* leave the quantity of 'capital' unaltered: then the two quantities of 'capital' would be at the same time equal, and different! Furthermore, during any disequilibrium transition the composition of capital would be changing; then maintaining the quantity of 'capital' unaltered from the first day to the second in terms of the first day's vector of capital endowments, and then maintaining the quantity of 'capital' unaltered from the second day to the third in terms of the second day's vector of capital endowments, would mean that the quantity of 'capital' would *not* remain unaltered from the first day to the third, in terms of the first day's vector of capital endowments, and it might even happen that the third day's vector of capital endowments be strictly superior to the first day's.

It is therefore impossible to specify the endowment of 'capital' of an economy, in a way that makes it legitimate to conceive of 'capital' as a single factor, given in 'quantity' independently of relative prices, and changing 'form' without changing in the given 'quantity' during the tendency to equilibrium([9]). A long-period marginalist general equilibrium is accordingly impossible to determine: the datum relative to the endowment of 'capital' is logically indeterminable.

§5.

It has been convincingly argued by Garegnani (1976) and Milgate (1979) that precisely some awareness of the inconsistencies besetting this traditional marginalist notion of 'capital', a single factor - an amount of value - embodied in the heterogeneous capital goods and capable of changing 'form' without changing in 'quantity', was the main reason for the shift to neo-Walrasian notions of equilibrium originating with Hayek, Lindahl and Hicks between 1928 and 1935. In these latter versions of marginalist theory, i.e. in the neo-Walrasian intertemporal or temporary equilibria, the endowments of the several capita1 goods are among the *data* of the equilibrium. The composition of the capital endowment is no longer determined endogenously by the equilibrium itself; it is given. The measurement of the given endowment of 'capital' in terms of a single number, an amount of value, is accordingly no longer there.

§6

But, as stressed by Garegnani (1976, 1990), the price paid for dispensing with that indefensible specification of the capital endowment is extremely high. The shift to the very-short-period neo-Walrasian notions of equilibrium (a shift entailing the abandonment of the traditional *method* - which had remained the same across the change in *theory* from the classical to the marginalist approach - which explains market prices and quantities as gravitating around and toward normal or 'long-period' positions characterized by a uniform rate of profits) introduces new and extremely grave difficulties:

[9]. The conditions for the Gorman-Fisher technical aggregability of heterogeneous capital goods into a single factor in the production functions would make it logically possible to determine the endowment of'capital' and its variations in physical terms, but are extremely restrictive (Bliss 1975, Ch. 7, F. Fisher, 1982, 1987): it must be as if, in all firms, the several capital goods (unassisted by labour) produced a single intermediate good K which then, together with labour, produced the firm's product, and furthermore, the 'production function' producing the fictitious good K must be the same in all firms. It can be shown that then, to all relevant effects, it is as if there were only one capital good.

1) The need to take subsequent changes in relative prices into account in determining the rates of return on current investment([10]) creates a dilemma between the absurd assumption of perfect foresight or complete futures markets over an infinite future, and the assumption of exogenously given expectation functions which entails a risk of indefiniteness of results, since the equilibrium comes to depend on largely arbitrary assumptions on expectations (thus e.g. Hicks in *Value and Capital, 1946, p.* 205, admits that the elasticity of price expectations to current prices can take on nearly any value and one can do little more than classify the possible outcomes).

2) The given composition of capital entails a very low substitutability between factors in the first period(s): changes in methods of production generally require, not

different proportions among the *same* capital goods or between them and labour, but rather the employment of different capital goods; thus, nearly certainly in the initial period of these very-short-period equilibria a very high proportion of equilibrium capital goods' rentals will be zero, the risk of a zero or implausibly low wage rate is very high, and very small changes in the relative endowments of capital goods may cause many equilibrium rentals, including perhaps the wage rate, to vary very considerably, often jumping from zero to positive or vice-versa; the prices determined by these equilibria cannot therefore aim at being good guides to observed prices**,** which do not exhibit such variability; which is the reason why Hicks in *The Theory of Wages* had written

> "In the short period, therefore, it is reasonable to expect that the demand for labour will be very inelastic, since the possibility of adjusting the organization of industry to a changed level of wages is relatively small.[...] Since the whole conception of marginal productivity depends upon the variability of industrial methods, little advantage seems to be gained from the attempt which is sometimes made to define a 'short period marginal product' - the additional production due to a small increase in the quantity of labour, when not only the quantity, but also the form, of the co-operating capital is supposed unchanged. It is very doubtful if this conception can be given any precise meaning which is capable of useful application." (Hicks, 1932, p. 21);

3) These equilibria cannot have the role, traditionally assigned to equilibria, of indicating the situation around and toward which market variables gravitate, and to

[10]. This need did not arise in long-period equilibria where, as explained in footnote 3 above, the adapted composition of capital made it possible to assume that the changes of relative prices over time would be slow enough to be normally negligible. In neo-Walrasian equilibria, on the contrary, the arbitrary initial composition of the capital endowment entails the possibility of very quick changes of relative prices, which must then be taken into account in the determination of the initial-period decisions.

which therefore on an average the economy can be taken to be reasonably close: before the economy has had time to correct or compensate the results of - to use Hicks's terminology - 'false price' tradings, the relative endowments of the several capital goods (and also, in temporary equilibria, the shape of expectation functions) can change to nearly any extent, and then, the data no longer being the initial ones, the economy cannot reach, nor gravitate around. the equilibrium corresponding to the initial data; the equilibrium itself has changed, owing to this change of the data; thus Christopher Bliss has written:

> "Does it not take time to establish equilibrium? By the time equilibrium would be established will we not have moved on to another 'week' with new conditions, new expectations, etc.?" (Bliss, 1975, p 210)

And Franklin M. Fisher has later declared (Fisher, 1983, p. 14, my italics):

> "In a real economy, however, trading, as well as production and consumption, goes on out of equilibrium. It follows that, in the course of convergence to equilibrium (assuming that occurs), endowments change. In turn this changes the set of equilibria. Put more succinctly, the set of equilibria is path dependent - it depends not merely on the initial state but on the dynamic adjustment process. Indeed, in the most general case with production and consumption there is even a hysteresis effect. [...] But even path dependence alone *makes the calculation of equilibria corresponding to the initial state of the system essentially irrelevant.* What matters is the equilibrium that the economy will reach from given initial endowments, not the equilibrium that it would have been in, given initial endowments, had prices happened to be just right."

But "the equilibrium that the economy will reach from given initial endowments" is unknowable, since we do not know what will happen during the disequilibrium. It cannot for instance be excluded (Garegnani, 1976) that, over a number of periods, there may be a cumulation of deviations of the actual path followed by the economy from the path which the economy would have followed if at the initial moment an Arrow-Debreu equilibrium had been instantaneously achieved.

§7.

Indeed, neo-Walrasian theory cannot tell us *anything at all* as to how actual economies behave, because it cannot make room for time-consuming disequilibrium adjustment processes. Within neo-Walrasian equilibria, when one abandons the realm of pure exchange and admits production and heterogeneous capital goods, then

stability cannot be studied except for fairy-tale adjustment processes involving no implementation of disequilibrium decisions; no conclusion derived from the study of these adjustment processes can be applied to economies where disequilibrium production decisions are implemented and can e.g. result in all sorts of multiplier-accelerator interactions, or in bankruptcies causing further bankruptcies, etc. So even if e.g. further research were to conclude that - contrary to what we now believe to be the case - the tâtonnement with 'tickets' under plausible assumptions is generally stable, one would still not know *anything at all* on the actual behaviour of real economies.

It is indeed unclear how one may hope to reach conclusions as to the behaviour of real economies, except on the basis of persistent forces making themselves felt through the vagaries of time-consuming disequilibria involving the actual implementation of disequilibrium decisions([11]).

One implication of the above argument is that no conclusion can be derived from neo-Walrasian theory as to whether actual economies do tend to the full employment of resources. Therefore neo-Walrasian general equilibrium theory cannot be the microfoundation of the thesis that market economies tend to the full employment of resources. Such a tendency must be argued to exist for real economies, and therefore it cannot be based on the study of the stability of the instantaneous, or timeless, adjustment processes which are the only ones compatible with the neo-Walrasian framework.

§8.

In order to find the real microfoundations of present-day neoclassical macroeconomics one must turn therefore to the older versions of marginalist theory, the ones attempting the determination of a long-period equilibrium, and based on the conception of capital as a single factor, an amount of value, embodied in the several capital goods.

[11]. Franklin Fisher (1983) has tried to investigate whether disequilibrium processes admitting disequilibrium transactions and productions might converge, but his results confirm the difficulties of neo-Walrasian theory: he can only prove convergence under the extremely restrictive hypothesis of No Favourable Surprise which in a discrete-time formulation would essentially amount to assuming rational expectations (cf. Madden, 1984); and the convergence may be to situations which have nothing to do with the equilibria of neoclassical theory (in other words, nearly anything can happen). Fisher has to admit, for example, that it is possible that the economy may get stuck in "a trivial sort of fixed-price equilibrium which occurs because nobody believes he can transact anything and hence does not try it. We shall *assume* this does not happen." (Fisher, 1983, pp. 151-2, emphasis added.) This confirms that, without persistent forces making themselves felt through the vagaries of disequilibrium, economic theory can have little hope to reach definite conclusions. (This footnote and the paragraph to which it is attached summarise an argument explained at greater length in Petri, 1993.)

In those versions the three methodological problems discussed in §6 did not arise. It was methodologically permissible to speak of time-consuming adjustment processes, because the equilibrium was endowed with sufficiently persistent data (as persistent as the data of the equilibrium of capital-less economies) and could therefore be seen as the fixed point and, if stable, the centre of gravitation of realistic, time-consuming adjustment processes; the substitutability problem did not arise, and the demand curve for labour could be thought to be sufficiently elastic, because the 'form' of capital was left free to adapt to the varying numbers of labourers to be combined with a given 'quantity of capital'; no complete futures markets needed be assumed, and expectations could be assumed to have had time to be corrected on the basis of experience. That the adjustment mechanisms were not always fast nor reliable was admitted, and in fact the empirical evidence on the existence of trade cycles was explained precisely in this way (think e.g. of Marshall, or Lavington); but it was concluded - and it was methodologically permissible to conclude - that over the cycle the persistent adjustment mechanisms pushing toward full employment could be seen as the dominant force and therefore the equilibrium could be seen as indicating the trend around which the economy fluctuated. This conclusion became questionable even within the traditional marginalist framework, after Keynes and the discovery of multiplier-accelerator interactions; but at least the theory was not blocked at the very start by the impossibility to consider any tune-consuming adjustment process. There was therefore no methodological obstacle to doing what the "neo-classical synthesis" and then monetarism did, i.e. to concluding that even accepting Keynes's framework, if time was given for mistaken expectations to be corrected, the liquidity trap became implausible and therefore in the long period the tendency toward full employment would be able to assert itself if money wages were flexible in the presence of unemployment ([12]).

[12].The theoretical victory of the anti-Keynesian counter-revolution was not complete, because it was not proven - nor has it been proven later - that the marginalist long-run equilibrating mechanisms would be generally strong enough to counter the disequilibrating influences coming from multiplier-accelerator interactions, vagaries of expectations, fanancial instabilities (Minsky) etc. Also, a number of authors (Kaldor, Joan, Robinson, and more recently Basil Moore and others) forcefully argued that the supply of money is nearly totally endogenous, the implication being that the monetary mechanism, which should lower the rate of interest if money wages decrease, cannot operate. A situation of theoretical uncertainty has resulted, which helps one understand why the rejection of the Keynesian 'principle of effective demand' (the principle that the equality between savings and investment is brought about by variations of the level of income and employment), and the re-establishment of an orthodoxy accepting Say's Law and the tendency to full employment at least in the long run, have been far from universal. But even among the critics of Say's Law only a small minority has raised the question: are those marginalist notions - accepted also by Keynes -, which made the neoclassical/monetarist counterrevolution possible, namely, the decreasing labour demand curve and the decreasing investment schedule, really as solid as mainstream macroeconomic theory takes them to be?

That the conception of capital as a single factor is what in fact lies behind standard macroeconomic theory is made clear by reflection on the two schedules which in that theory make it possible to argue that the 'real' forces at work in market economies push them toward full employment: the labour demand curve, a decreasing function of the real wage; and the aggregate investment schedule, a decreasing function of the interest rate.

§9.

What is taken as given when drawing an aggregate labour demand curve? This curve aims at showing, for each level of the real wage, the labour employment toward which one may expect actual employment to gravitate (assuming price flexibility and stability in all other markets) if the real wage stays fixed at the given level. It is therefore the curve implied by the corresponding solutions of a general equilibrium model where the equation "demand for labour = supply of labour" has been eliminated and in its place the real wage is treated as a parameter, and where furthermore the income, from which the demand for final goods comes, is the income of the employed factors only([13]). What are we to take as the fully employed endowment of capital in this exercise in general equilibrium comparative statics? The use to which the curve is put - to exhibit the effects of persistent changes in the real wage on labour employment - shows that what is taken as given cannot be the endowments of each different capital good, including nails, screws, component parts of final goods only waiting to be assembled, etc.: these endowments would have no persistence, being susceptible of drastic changes in even only a few hours, so the labour demand curve based on them would have no validity for assessing the effects of changes in the real wage on labour demand; also, the curve would be extremely

[13]. So unemployed workers do not demand final goods (except with income from sources other than their labour); for each level of the real wage, the economy is in equilibrium on all markets except the labour market, Walras's law as normally intended does not hold (there is disequilibrium on only one market), because the demand for final goods is not based on the income consumers *count on* obtaining from their desired supplies of factors (as is on the contrary the case in the tâtonnement with 'tickets'), it derives only from the income they actually obtain. (The spread of neo-Walrasian notions of equilibrium and of the habit of conceiving the equilibrium as reached by a tâtonnement evidently obscured this assumption implicit in the derivation of the traditional labour demand curve, to the point that Clower's re-discovery of it, under the name of 'dual-decision hypothesis', was hailed as a great analytical advance.) Clearly, if one cannot assume that all workers are identical, this traditional labour demand curve is somewhat indeterminate outside the full-employment equilibrium point, in so far as the composition of demand, and hence the demand for labour, are affected by precisely *which* workers remain unemployed if labour supply is greater than demand, or by which hypotheses one makes as to the tastes of the imaginary workers employed in excess of the supply of labour if labour demand (and hence employment) is greater than supply. But what is important for traditional analysis is, essentially, that the curve be decreasing, and this is not affected by the above indeterminacy.

inelastic, suffering from the nearly total absence of substitutability between labour and capital goods once the 'form' of capital were completely specified (cf. difficulty 2 in §6 above), so it would generate implausible equilibrium levels of the real wage. No, what is actually, more or less explicitly, taken as given when drawing that curve is the amount of 'capital' of which the economy is endowed, treated as a single factor of variable 'form'. The validity of that traditional conception of 'capital' is taken for granted. And indeed, if that conception were not in the background, it would be unclear why the change in the composition of capital associated, over any reasonable time period, with a changed real wage, should always entail a change of the demand for labour of opposite sign to the change in real wages. If the several capital goods were not seen as elements of a single factor 'capital' employed in a given quantity, and whose optimal ratio to labour increases with the real wage (i.e. decreases when the rate of interest increases), it would be unclear why the disappearance of some kinds of capital goods and the appearance of different ones, normally associated with the changes in cost-minimizing techniques brought about by a change in real wage, should always entail a change in the demand for labour of opposite sign to the change in real wage.

It is sometimes thought that the labour demand schedule can be derived, in a Marshallian or Keynesian short period, by taking the fixed plants, or more generally the durable capital stocks, as given in physical terms, while the amounts of circulating capital goods (work-in-progress, in Keynes's terminology, or intermediate goods) are endogenously determined (thus admitting that, in order for additional labour to produce more, more intermediate products must also be present). In this way the need for an endowment of 'capital', an amount of value, would not arise, and the inelasticity due to a completely specified 'form' of capital would be somewhat reduced. The labour demand schedule would then indicate the value of the *net* marginal product of labour**,** i.e. its value marginal product minus the cost of the additional work-in-progress necessarily associated with the increase in product([14]); and it would be argued that the marginal product of labour-cum-intermediate-goods cannot but be decreasing, at least after a certain point, if the amounts of durable capital goods are given. But such a construction is also subject to decisive criticisms.

First, serious problems arise in delimiting the kinds of capital goods whose stocks might be treated as given. There appears to be no single clear-cut divide between kinds of capital goods as to the speed with which their endowments can change, but rather a continuum, so that any separation of capital goods into two

[14]. This cost would be determined by cost of production, inclusive of the rate of interest. The latter would be determined by the ratio between value net marginal product and cost of production of those, of the durable capital goods, of which there were positive production.

categories, one with given endowments and one with endogenously determined endowments, appears arbitrary.

Second, as is well known from the literature on full-cost and mark-up pricing and from the studies on the real wage in the trade cycle([15]), if fixed plants are given and what varies with labour employment is the degree of their utilization, then the net marginal product of labour is in most cases not regularly decreasing, but rather constant or even increasing (as shown by the constancy or diminution of marginal cost) up to a seldom reached full-utilization level, after which it falls very abruptly. Firms therefore do not equate price and marginal cost, but rather fix prices by adding to prime cost a mark-up so as to cover fixed costs and obtain at least the normal rate of return, and adapt production to demand. Then a decrease of the real wage in terms of the product does not imply an increased demand for labour with the given fixed plants. The only way to obtain the regularly decreasing labour demand schedule which standard theory needs would therefore appear to be, to argue that long-period technical choices (changes of fixed plants) are sufficiently present in any short *run*([16]) as to make their character felt even in the short run: but then the short-run demand curve for labour would be downward-sloping not *because* of the short-run nature of the analysis, but rather *in spite of* it, and would be again based on long-period analysis, i.e. on the notion of 'capital'-labour substitution.

Third, any result reached on the basis of the assumption of given endowments of some capital goods is bound to have at most temporary validity, and to be modified to a greater and greater extent, as time passes, by the increasing influence of long-period choices. Indeed, since in any given time period, however short, there will always be long-period choices being made together with short-period choices, and since it is generally accepted that in the short period the possibilities to alter labour employment are more limited than in the long period, then unless short-period and long-period choices act in the same direction it seems highly doubtful that one could ever find a period-length short enough for the short-period choices clearly to dominate over the long-period ones, and yet long enough for the short-period choices to dominate over the accidents and vagaries of day-by-day disequilibria. In the dominant macro analyses this problem does not appear because short-period and long-period choices as to labour employment are thought to be in the same direction; the demand for labour is simply seen as more elastic in the long than in the short run. But the

[15] For recent enquiries which reassert what had already been argued by Dunlop and Tarshis against Keynes, i.e. that there is little or no evidence that real wages decrease when employment increases, cf. Zenezini (1990), Brandolini (1995).

[16]. In order to prevent confusions, it is better to use a different term, such as 'short run', to refer to actual lengths of time, while reserving the terms 'short or long period' for the analytical distinction as to whether the 'form' of capital is assumed at least partly fixed, or entirely variable.

long-period demand for labour, in these analyses, is based on the traditional notion of long-period 'capital'-labour substitution. If that traditional notion were rejected, then even if it were possible to demonstrate that the demand for labour is decreasing if based on given fixed plants, the possibility that long-period choices might go in the opposite direction to short-period choices would make the short-period analysis of doubtful relevance, since the short-period choices, being of more limited elasticity, would be quickly dominated by long-period choices.

Thus the recourse to the short period is of no avail. The only plausible way for a marginalist economist to defend the standard labour demand curve is by appealing to the long-period, traditional, marginalist analysis of 'capital'-labour substitution.

§10.

The faith in the traditional conception of 'capital' is even clearer in the treatment of aggregate investment. The already-cited survey by Chirinko states:

"The Benchmark Model is based on a demand for capital and, with the addition of dynamics, a demand for investment. The demand for capital is derived from elementary economic principles, and is determined by the equality between the expected marginal benefits and costs from an additional unit of capital" (Chirinko, 1993, p. 1877); "As discussed throughout this survey, a fundamental issue in investment research is the translation of the demand for the stock of capital into a demand for the flow of investment" *(ibid., p* 1905)([17])

Chirinko here is simply following the standard approach to investment, where the traditional conception of capital as a single factor, of variable 'form', is uncritically accepted. It would seem nonetheless that some aspects of that conception are not fully grasped in the literature on investment of the last fifty years. The issue of "the translation of the demand for the stock of capital into a demand for the flow of investment", which has prompted a considerable mass of theoretical writing, is in fact simpler than it is usually made to be, if that conception of capital is accepted.

The standard argument is that a change in the rate of interest changes the desired *stock* of 'capital', but that this is not enough to determine the *flow* of

[17].Many other quotations to the same effect could be produced. Junankar in his 1972 survey of investment theory is very candid on how aggregate capital is to be measured: "There are several problems involved in measuring aggregate capital stock [...] Cambridge economists have argued very strongly that it is impossible to measure capital in value terms in a way that is independent of the rate of interest and wages. For the purposes of this survey I shall sidestep this controversy and *assume* that we can measure capital in value terms." (Junankar, 1972, pp. 12-13, my italics.) Nearly all other authors do not even bother to mention the Cambridge controversy and the questionable nature of the measurement of capital in value terms.

investment, which will depend on the speed with which entrepreneurs desire to reach the new optimal capital stock:

> the demand for investment cannot simply be derived from the demand for capital. Demand for a finite addition to the stock of capital can lead to any rate of investment, from almost zero to infinity depending on the additional hypotheses we introduce regarding the speed of reaction of capital users (Haavelmo, 1960, p. 216). (Also see Lerner, 1944, pp. 330-33, 338.)

But this problem in essence disappears once it is admitted that 'capital' cannot change its 'form' except gradually, through the replacement of worn-out capital goods with different capital goods (cf. Garegnani, 1978). Fixed plants, once in existence, will be maintained in operation as long as they yield non-negative quasi-rents; and the amount of labour they require for normal utilization will generally be very rigid. So, after a change in the rate of interest, labour employment in the already existing plants will continue much as before, at least as long as the quasi-rents have not become negative. There is therefore no immediate incentive for firms to alter their plants, if these still yield non-negative quasi-rents. Only as the older plants reach the end of their economic life and are thereby closed down, and the corresponding labour employement becomes 'free' to be re-employed in new plants, will entrepeneurs desire to employ the 'free' labourers in plants embodying the new optimal 'capital'-labour ratio. So investment in fixed capital is determined by the desired K/L ratio *on new plants*, the amounts of new plants being in equilibrium the one necessary to employ the flow of labour 'freed' by the gradual closure of the plants reaching the end of their economic life. So if e.g. every years one-tenth of the available labour force is 'freed' by the closure of old plants, after a change of the interest rate yearly gross investment will be the one necessary to build the plants allowing that one-tenth of the labour force to be reemployed with the techniques corresponding to the new optimal K/L ratio, i.e. to build one-tenth of the plants which will finally constitute the new capital stock of the economy when all old plants will have been replaced by new ones embodying the new K/L, ratio. The gross investment schedule will therefore be a scaled-down copy of the 'capital' demand function, the scale factor depending on the average durability of capital, and it will be downward-sloping because the 'capital' demand curve is downward-sloping.

> "The theory implies that such circumstances as delayed adjustments in the markets for labour and products, or irregularity in the age distribution of fixed capital, do not fundamentally alter the terms of the question. As a result, the interest elasticity of the

> sequence of demands for investment would reflect, on average, the elasticity of the demand for capital as a stock. Hence the significance of a demand for capital as a stock which exhibits, in a clear form, the basic tendencies which must emerge from the multiplicity of forces acting in any given moment of time." (Garegnani, 1978, p 353([18])

§11.

The investment function (which is nothing but the demand-for-savings schedule) derived in the way suggested above necessarily relies on the traditional conception of capital as a single factor, an amount of value. Just as with the labour demand curve, one may ask whether a decreasing investment schedule might not be derived within a short-period or temporary equilibrium framework without reference to 'capital'. On this issue an important contribution is Garegnani (1978), who argues that, if one entirely abandons the reliance on traditional long-period marginalist analysis and on the notion of 'capital' the single factor, then "it would be difficult to see how we could ever provide any theoretical basis for the notion, plausible as it may seem, of a demand function for investment elastic with respect to the rate of interest" (Garegnani**,** 1978**,** p**.** 36): the reaction of investment to changes in the interest rate would depend on a myriad of elements, for example on how changes in the rate of interest will influence the economic life of existing capital, or on how they will influence the investors' expectations. Garegnani does not supply examples, but it is not difficult to conceive of instances in which these influences may go in what a neoclassical economist would call a 'perverse' direction: it might e.g. happen that the price changes, induced by an *increase* of the interest rate, make it convenient to anticipate the replacement of part of the existing durable capital, inducing an *increase*

[18]. Garegnani indicates, as evidence that this is a correct reconstruction of the implicit views of the older marginalist authors, Marshall's distinction between "quasi rent on an old investment of capital" and "interest on free capital", cf. Marshall, 1920, V.9.3, also VI.2.6 and VI.6.6, and Wicksell's analogous concept of "free" capital, cf. Wicksell, 1935, p. 192 "Free" capital is the supply of gross savings (the sum of depreciation allowances and of net savings), to which the rate of interest causes gross investment to adjust. This notion reflects the view that "In any given instant the available 'capital' will not in fact be a 'fluid' which may quickly assume a form compatible with the conditions corresponding to any point of the demand function for capital. On the contrary, in any given instant 'capital' is incorporated in a given set of capital goods and it can only assume the appropriate physical form over a period of time during which most of the capital goods in existence are consumed and the available capital becomes 'free' to be reinvested in capital goods suitable for use with other techniques or in other productive sectors" (Garegnani, 1978, p. 35). The neglect of this aspect of the traditional conception of 'capital' in favour of an absurd view of 'capital' as a fluid instantaneously adaptable to different K/L ratios ('putty-putty'), is what explains the opinion, sometimes entertained by marginalist authors, that the investment schedule cannot but be extremely elastic with respect to the interest rate (because the flow of investment can only very slowly alter the marginal product of 'capital'; so an interest rate lower than the marginal product of'capital' would induce a desire to increase the K/L ratio on all labour employment, enormously stimulating the flow of investment).

in investment; or it might happen that *a decrease* in the interest rate causes expectations of further decreases, inducing a postponement, i.e. a *decrease*, of investment. Thus Garegnani appears justified in concluding:

> "The attempt to determine the effects on investment of changes in the rate of interest on such indefinite grounds would seem liable to dissolve into casuistry concerning the influence of these changes on the expectations of entrepreneurs. And this influence would differ from situation to situation, thus making impossible any general and unambiguous conclusion concerning direction and intensity of the effects of interest on investment." (Garegnani, 1978, pp.36-37)([19]).

Therefore the only way to argue that even in the short run aggregate investment is a decreasing function of the rate of interest would appear to be, by admitting that, even in the short run, the main influence on investment decisions comes from long-period forces, i.e. from the 'capital' demand function, in the way indicated above. The scale-copy investment function is then the basis - indicating the persistent forces - on which one may superimpose short-period complications (e.g. oscillations of me state of confidence, or credit market complications, or irregular replacement needs, or "bunching" of innovations), as in the marginalist analyses of the trade cycle prior to Keynes. But then, again, investment will be a decreasing function of the interest rate if at all - in *spite of* the short-period nature of the analysis, in so far, that is, as the complications and accidents of the short period do not counterbalance the long-period influence. The reliance on the traditional conception of 'capital' is then clear.

§12.

In the second Part of this paper it will be shown that Garegnani's thesis - the impossibility of justifying, without recourse to the traditional long-period marginalist forces, a negative elasticity of investment with respect to the interest rate - remains valid vis-à-vis some more recent theories of aggregate investment. One can then easily appreciate the importance of the results of the Cambridge controversies on capital theory. In §4 above it has been shown that the measurement of 'capital' in units independent of distribution([20]) is impossible (except in totally special cases). It should

[19]. This also explains the lines by Garegnani (1978) quoted at the end of §10. Unless the marginalist authors believed in the dominance of the long-period forces over the disturbances mentioned there by Garegnani, they could not have proposed their theory of investment.

[20].And of the choice of numéraire, but it is because relative prices change with distribution, that the choice of numéraire affects the measurement of 'capital'.

be clear that the notion of 'capital'-labour substitution is then also impossible to define, because if 'capital' cannot be measured independently of distribution, then the 'capital'- labour ratio cannot either.

The results of the Cambridge controversy provide further support for these conclusions, by showing that

(a) if a technique is considered more 'capital'-intensive than another one when in the long period the economy switches from the first to the second because of a rise of the interest rate, then a technique may be more or less 'capital'-intensive than another one depending on the level of the interest rate; therefore the relative 'capital'-intensity of alternative techniques cannot be considered a technological datum([21]);

(b) if 'capital' is measured as an amount of value (e.g. in terms of a given net product), then, as Garegnani (1970) and others (e.g. Burmeister and Dobell, 1970, pp. 291-2) have shown, long-period technical choices can cause the 'capital'-labour ratio to be nearly any function of the rate of interest; it can be increasing ("capital reversal"), or it can alternate increasing and decreasing portions; it can even be constant in spite of continuous change of techniques as the rate of interest varies; it cannot therefore be interpreted as the demand curve which, in connection with the supply curve, should determine the equilibrium level of the rate of interest([22]).

[21] This has been definitely proved by Sraffa's discovery of reswitching. Recently Andreu Mas-Colell (1989) has provided further support for these anti-neoclassical findings by showing that, in a multi-sector economy, the long-period net product per unit of labour can be any function of the interest rate. So as the interest rate rises, long-period technical choices may be such that the net product per unit of labour rises and then decreases and then rises again: then if one wanted to conceive the heterogeneous capital goods as embodying a single factor 'capital', one would have to conclude that a higher and higher rate of interest may induce firms to employ at first more 'capital' per unit of labour (if more net product per unit of labour must mean that more 'capital' is being combined with each unit of labour), then less, then again more, etc This would go against any theory of cost minimization, showing the absurdity of such a conception of 'capital'. The habit of thinking of capital as somehow a single factor, with a decreasing technical marginal product definable independently of income distribution, must definitely be abandoned.

[22] To see why, let us assume that there are only two factors and let us remember that the standard demand curve for a factor is supposed to tell us the amount of that factor which entrepreneurs find it convenient to combine with the given and fully employed endowment of the other factor; but if this curve, not being decreasing or sufficiently elastic, does not yield with sufficient probability a unique and stable equilibrium with realistic values of the distributive variables, the symmetrical demand curve for the other factor will not do so either; it is then problematical to justify the assumption that this second factor will be fully employed (indeed, it will be argued below (§21) that if labour demand cannot be assumed to increase significantly when the real wage decreases, then the assumption of indefinite flexibility of wages becomes difficult to justify, what suffices to make the assumption of a tendency to full employment impossible to maintain); but then the 'demand curve' for the first factor, based as it is on the assumption that the second factor is fully employed, cannot indicate the demand actually forthcoming for the first factor. When this reasoning is applied to the demand curve

Result (a) entails, among other things, that there is no index of 'capital' which is independent of distribution and which makes the demand for 'capital' (per unit of labour) generally a decreasing function of the interest rate. Result (b) confirms that the same is true for the measurement of 'capital' as an amount of value. The latter result implies that, even if one conceded the full employment of labour and neglected the arbitrariness of the choice of numéraire i.e. conceded that there is a numéraire which can be chosen without excessive arbitrariness to measure the *supply* of savings, the problem would remain that the *demand* for savings - the investment schedule - deriving from long-period forces would not be a regularly decreasing function of the interest rate. The thesis that the rate of interest can act as the price bringing the savings-investment market into (a unique and stable) equilibrium thereby loses plausibility.

Analogously, even if one conceded for the sake of argument the legitimacy of measuring the endowment of 'capital' of an economy as an amount of value and the legitimacy of assuming it to be fully employed, it would not follow that the labour demand curve would be downward-sloping, with a consequent lack of plausibility of the tendency to a full-employment equilibrium on the labour market([23]).

The above results - reswitching and reverse capital deepening - are admitted by both sides to the Cambridge controversy. The non-aggregability of heterogeneous capital into a single factor is universally acknowledged. Nonetheless, mainstream macroeconomic theory goes on much as before. The main reason for this state of affairs is no doubt that the necessary reliance of mainstream macroeconomics on the traditional conception of 'capital' as a single factor, an amount of value, is not fully

for 'capital', the assumption of labour full employment becomes even more difficult to justify, because, the endowment of 'capital' being indeterminable, the demand curve for labour cannot be determined either, what makes the equilibrium between supply and demand on the labour market impossible to determine, undermining any argument in support of a tendency to such an equilibrium.

[23] It might be objected that if an equilibrium is unstable, then there generally are other equilibria which are locally stable: e.g. if the only equilibrium with both positive wage and positive interest rate is unstable because labour supply is rigid (vertical) while labour demand is everywhere upward sloping, there will be two locally stable equilibria, one corresponding to a zero real wage and the other one to a zero interest rate: and both, the argument might continue, are full-employment equilibria for the factor with non-zero rental. True; but if a theory predicts as perfectly likely that market economies may tend to situations where income goes entirely to capital or entirely to labour, then clearly the theory is wrong on the mechanisms at work in real economies. More generally, multiple equilibria would seriously undermine the explanatory plausibility of the theory, entailing, as they would do, the possibility of persistent changes in distribution due to purely accidental and transitory causes - something which appears to have no correspondence to observed events. This is admitted e.g. by Kirman (1989). To this one may add that the assumption of indefinite wage flexibility becomes difficult to justify (cf. § 21 below), and finally, that the assumption that one can take the endowment of 'capital' as given was for the sake of argument only.

perceived. The opinion appears to be widespread that macroeconomic theory is based on Solovian one-good models only for the sake of simplicity, and might if necessary be re-cast in terms of fully disaggregated, neo-Walrasian models. The main purpose of the argument up to this point was to show that this opinion is mistaken. Neo-Walrasian models *assume* Says Law and the full employment of resources: they cannot *justify* these assumptions. The justifications are rather to be found in the macroeconomic literature, and they rest on the view of investment as a decreasing function of the interest rate. This view of investment cannot be defended on the basis of the traditional marginalist conception of 'capital'. Are there other ways to defend it? This issue is examined in Part II.

PART II: *Other derivations of a negative elasticity of investment with respect to the rate of interest.*

§13. *Keynes.*

The above reconstruction of the approach to investment implicit in the traditional marginalist theory of value and distribution makes it clear that that approach was based on the hypothesis of full employment of labour. Keynes dropped that hypothesis. This makes his continued belief in a downward-sloping investment schedule difficult to justify even on marginalist terms. If labour employment can increase together with the stock of 'capital', the marginal product of 'capital' need not decrease with capital accumulation; indeed, if future labour employment is *not* given, the marginal product of the future stock of 'capital' is not determinate.

Yet Keynes appears to attribute to the decrease of the marginal product of 'capital' the decreasing shape of the investment schedule, if one leaves transitory elements aside. The well-known passage is:

> "If there is an increased investment in any given type of capital during any period of time, the marginal efficiency of that type of capital will diminish as the investment in it is increased, partly because the prospective yield will fall as the supply of that type of capital is increased, and partly because, as a rule, pressure on the facilities for producing that type of capital will cause its supply price to increase; the second of these factors being usually the more important in producing equilibrium in the short run, but the longer the period in view the more does the first factor take its place" (Keynes 1936, p. 136)([24])

[24] The Mashallian origins of this passage perhaps help one explain Keynes's inconsistency. Marshall had nowhere explicitly discussed an aggregate investment schedule with characteristic empiricism, he had only explained investment by reference to the convenience of

It is possible that the problem, which such an explanation meets when labour employment is not given, motivated the subsequent search for justifications, of the decreasing investment schedule, not directly based on 'capital'-labour substitution. The main such justifications are summarised and criticised below.

§14. ***The array-of-opportunities approach***.

A number of authors, including Marglin (1970), Pasinetti (1974, p. 37), Samuelson-Nordhaus (1985, Ch. 7), propose an "array-of-opportunities" approach([25]), whose presentation makes no explicit connection with the marginalist analysis of 'capital'-labour substitution, and which is claimed by many of them to be independent from that analysis.

Each firm or entrepreneur, it is argued, at any given point in time is "aware of a considerable number of possible investment projects, for each of which it can calculate, given its best estimates of all the relevant variables, its marginal efficiency"([26]) or MEC (marginal efficiency of capital, i.e. expected internal rate of return, derivable from the project's prospective net income stream); the entrepreneur will find it convenient to implement all the projects whose MEC is higher than the rate of interest. The aggregate investment function is, for each level of the interest rate, the sum of all the projects the entrepreneurs decide to implement. The lower the interest rate, the more projects have a MEC greater than the interest rate, so the investment function for the individual investor is a decreasing step function. In all likelihood the jumps are at different levels of the interest rate for different firms or industries, so the aggregate investment schedule is close to being a continuous downward-sloping curve.

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investing in each capital good, like in the following passage: "so long as the resources of an individual producer are in the form of general purchasing power, he will push every investment up to the margin at which he no longer expects from it a higher net return than he could get by investing in some other material, or machine, or advertisement, or in the hire of some additional labour: every investment will, as it were, be driven up to a valve which offers to it a resistance equal to its own expanding force." (Marshall, 1970, V, viii, 6, pp. 340-341). Keynes takes from Marshall this approach to investment in terms of individual capital goods: this made it perhaps easier for him to forget that the argument that "the prospective yield will fall as the supply of that type of capital is increased", which is valid for an increased supply of a single capital good under a 'ceteris paribus' assumption, no longer holds if investment in all capital goods is expanded together with the employment of labour and with aggregate demand. Nor can one argue that Keynes was thinking of an aggregation of decisions of investors at a single instant, i.e. before the results of the interaction of their investment decisions became manifest and brought about a correction, cf. below, fn. 32.

[25] I borrow the term from Witte (1963, p. 445) and Junankar (1972, p. 23).

[26] Ackley (1978, p. 622). Ackley is highly critical of the approach.

In these presentations, no discussion is supplied of how the prices, on the basis of which the MECs of the various investment projects are determined, should be assumed to change with the rate of interest: the fact that the ranking of the projects and even their internal rates of return are taken as given independently of the level of the interest rate obliges one to interpret the "array-of-opportunities" approach as assuming that the prospective net yields (gross of interest payments) of the various investment projects are given independently of the level of the rate of interest, i.e., that expected relative prices are assumed to be independent of the level of the interest rate([27]).

It is not essential to our purposes to discuss whether - as some of these authors claim - such an analysis correctly describes Keynes's own reasons why the MEC

schedule is decreasing. Be it what Keynes meant or not([28]), it has been argued to be a consistent motivation for a decreasing investment schedule, and this is the claim we must examine.

A decisive criticism has been, in various forms, enunciated by numerous authors, so it is surprising that it should not be discussed by the proponents of this approach. It was most succinctly put as follows: "If one way of using capital is more profitable than others, why employ the other methods at all?" (Witte, 1963, p 445) ([29])

The point is that there cannot be, in equilibrium, investments which yield a higher rate of return than the interest rate. At any given moment some investment projects will offer better yields than the interest rate, and some, worse yields, because of disequilibrium phenomenon and only allows an explanation of which sectors see

[27] The array-of-opportunities approach is therefore not to be confused with the increasing-supply-price argument to be discussed in §16 below in the latter, to each level of the interest rate and hence of aggregate investment there corresponds a different supply price of investment goods, hence a different rate of return on *all* investment projects.

[28] Pasinetti (1974, p. 43) writes: "Keynes' ranking of all investment projects in a decreasing order of profitability is more akin to Ricardo's ranking of all lands in a decreasing order of fertility than to any marginal economic elaboration". The nature of the analogy with Ricardian rent is unfortunately not further clarified: where is the scarcity element here which causes the reduction in yields? This and other attempts to argue that Keynes's "marginal-efficiency-of-capital schedule, which might, at a first superficial look, appear as belonging to marginal economic analysis, when examined more deeply turns out to have a rather different origin" (Pasinetti 1974, p. 43) run against the difficulty that Keynes himself saw his MEC as just another way of formulating the standard, i.e. marginalist, analysis of the *demand for capital:* "Nor is there any material difference, relevant in this context, between my schedule of the marginal efficiency of capital or investment demand-schedule and the demand curve for capital contemplated by some of the classical writers who have been quoted above" (Keynes 1936, p. 178: Keynes uses "classical" to mean essentially "marginalist", the authors he is referring to are Marshall, Cassel, Walras, Taussig, and elsewhere Pigou and Wicksell).

[29] For a detailed explanation, cf. Ackley (1978, pp. 623-4: I highly recommend the whole chapter to which these pages belong, as perhaps the best discussion ever of investment theory by a marginalist author). Also cf. Ackley, 1961, pp.472-3, note 6; and Junankar, 1972, p.23.

investment in them increase and which ones see it decrease as part of the tendency toward equilibrium, not an explanation of the level of total investment nor of how that level will change with the interest rate. For the latter explanations, one must look at equilibrium decisions, and these are taken at zero-extraprofit prices, because, through variations of relative product prices and factor rentals, competition will ensure that all the investments adopted yield the same rate of return, equal to the interest rate. That these variations are going to happen is easy to see. In the case of perfect competition, current and expected prices are taken as given by each individual investor (expected prices being determined by his own expectation function). Investment projects must then appear to the individual investor as replicable without limit, since - in the hypothesized price-taking conditions - he cannot expect difficulties in getting factors nor in selling the product at the current or expected prices. Therefore the investment function for the single entrepreneur treating prices as given is a horizontal straight line: it yields an infinite investment if even only one project has a MEC greater than the interest rate, zero investment if no project has a MEC at least equal to the interest rate, and an indeterminate investment if only one project has a MEC equal to the interest rate. Therefore an investment project with a MEC higher than the interest rate will be replicated, tendentially without limits, with a consequent excess supply of the goods produced by those investment projects. The prices of those goods cannot then be assumed to remain unchanged. (Even if individual firms were assumed to encounter decreasing returns to scale after a certain dimension - an implausible assumption anyway -, the *number* of firms could not be taken as given: investment may well consist in the creation of new firms: so it would be new firms which would replicate the profitable projects infinite times.) Free entry of firms will ensure that the same result also holds in imperfectly competitive industries.

In so far as the investment schedule aims at abstracting from the accidental and transitory influences of very-short-period disequilibria, one must therefore assume that to each level of the interest rate there are associated different product prices and a different level of the real wage: the ones required by zero extraprofits.

But then it is not possible that a lowering of the interest rate should make the previously adopted investment projects more profitable and should furthermore induce the addition, to them, of previously unprofitable investments: if the change in the rate of interest affects investment, it must be because the old investment projects stop being profitable and are replaced by *different* projects([30]): then a theory is needed

[30] . This is precisely the case in the traditional versions of marginalist theory, where the change in interest rate induces the adoption of different technolog1es, with a different capital-labour optimal proportion: the old technology stops being convenient, and the new technology, given the full employment of the flow of labour "released" by the closure of old plants, determines a higher demand for "free" capital.

explaining why the change in the most profitable investment projects is such that to a lower rate of interest there corresponds a higher aggregate investment.

One implication of the above reasoning deserves repeating, because it will be important again and again in the sequel. *The assumption, that the returns to individual investment projects are given independently of the level of the interest rate, is not acceptable* (Garegnani, 1979, p. 60, fn. 45; Pivetti, 1985, p. 98). The expected relative prices implicit in each point of the aggregate investment schedule must be zero-extraprofit prices, i.e. cost-of-production prices; and therefore they must vary with the interest rate. It follows that, in the calculation of the internal rate of return or present value of investment projects, to take the streams of net returns of the investment projects as given independently of the level of the interest rate is illegitimate([31]).

These considerations cannot be pushed aside by arguing that the analysis is intended to be a very-short-period one, concerned with expectations and investment decisions at a point in time (then, it is sometimes argued, expected prices are given, because they reflect the agents' expectations at that point in time). Even if one tried to predict investment at a point in time, one would have no right to consider expected prices as not changing, in the face of variations of the interest rate which are expected to last. The returns relevant to an investment project are usually spread out over a considerable length of time, and therefore investors must be presumed to take into account the predictable price changes associable with changes of the interest rate. Anyway the fruitfulness of trying to explain and predict investment moment by moment is more than doubtful, because at each moment investment will be influenced by expectations which may depend on the whims and accidents of the moment and which are admittedly shortly to be revised, and by any other sort of accidental and transitory causes: these influences will make it impossible to predict the effects on investment of a change in the rate of interest or in other variables; also, investment decisions can be reversed or modified, and, if the expectations motivating the original decisions turn out to be incorrect, will usually be reversed or modified, even if this causes a cost; so the determination of investment decisions at a point in time is uninteresting. The analysis must therefore aim at determining the persistent forces acting on investment, and thus the average, or trend, of aggregate investment emerging from the multitude of temporary influences([32]). If one wants to explore the

[31] . This is not often admitted, but see e.g. Jorgenson (1967, p. 152), quoting Alchian (1955). One important implication is that a lower interest rate will entail a higher real wage, not necessarily because the demand for labour will increase: with a given money wage, the higher real wage will be brought about by price-cutting competition by firms whose costs have been lowered by the decrease in interest rate.

[32] This would appear to have been also Keynes's opinion, as expressed in a letter to Kalecki dated 12 April 1937 "I hope you are not right in thinking that my *General Theory* depends on an assumption that the immediate reaction of a capitalist is of a particular kind. I tried to deal with this on page 271 [? probably 261], where I assume that the immediate reaction of

persistent influence of the interest rate on investment, one must therefore give time to the changes in interest rate to affect relative prices and distribution.

A brief consideration may now be given to the argument, that the problem of infinite investment if prices are given might be avoided by assuming that entrepreneurs are conscious that they can only sell more at a lower price, that is, by assuming generalized imperfect competition. Such an assumption would make it possible to argue that the indefinite replication of an investment project encounters a limit in the decrease of the expected returns due to the decrease of the expected selling price; the decreasing shape of the investment schedule would be then derived from given demand curves for the single firms; a decrease of the interest rate would shift the cost curves downwards and thus would make it convenient to sell more at a lower price, and therefore to increase productive capacity. But what may cause the demand for a product to increase if its price decreases is the fact that the product has become more convenient *relative to other products.* If, following a lowering of the interest rate, all products decrease in price, then relative convenience will not be altered at all if relative prices do not change (all demand curves shift downwards in the same percentage as costs), and, to the extent to which they change, the shift rightward of the demand curve for some products will be compensated by the shift leftward of the demand curve for other products, so, in the aggregate, demand does not change([33]). Besides, if all invest more, then aggregate demand increases, therefore all demand curves shift to the right, so not only it is unclear why a decrease in the interest rate should be a *sufficient* condition for an increase in investment, it is also unclear why it should be a *necessary* condition for greater investment.

§ 15. ***Kalecki.***

Another derivation of a decreasing investment function, making no reference to the 'capital' intensity of production, might rely on Kalecki's "principle of increasing risk". Kalecki's analysis is unconvincing, but on this issue space limitations oblige me to refer the interested reader to Petri (1993b).

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capitalists is the most unfavourable to my conclusion. I regard behaviour as arrived at by trial and error, and no theory can be regarded as sound which depends on the *initial* reaction being of a particular kind. One must assume that the initial reaction may be anything in the world, but that the process of trial and error will eventually arrive at the conclusion which one is predicting." (Keynes, 1973-79, vol. XII, p. 797).

[33] . See Ackley, 1978, p. 624. I am leaving aside here the argument that employment will anyway increase owing to the real balance effect due to the lower price level, because such an argument (which does not require imperfect competition) is irrelevant for the shape of the investment schedule. One may nonetheless notice that there seems to be a consensus that real balance effects are too weak and too fraught with dynamical difficulties to re-establish a faith in the tendency to full employment, cf. Patinkin (1987).

§ 16. ***The "short-period increasing supply price" approach.***

In the first decades after the *General Theory,* Keynes's short-period rising-supply-price argument was raised, e.g. by Lerner (1944), Ackley (1961; 1978, p. 629), Witte (1963), to the role of only true responsible for the decreasing shape of the investment schedule. The argument, an implicit criticism of Keynes, was that, since investment can only very slowly change the existing capital stock, the *rental* of capital cannot rapidly change and therefore one cannot attribute the declining shape of the MEC schedule (which Lerner renames *Marginal Efficiency of investment,* MEI, reserving the term MEC for the long-period curve of the marginal product of capital across stationary states) to a decrease of the prospective yield of capital goods when investment increases; that yield must be assumed to be essentially constant, depending on the existing stocks, the supply price of capital goods, though, will increase with their rate of production owing to short-run increasing marginal costs, and this will put a limit to investment([34]).

But Ackley (1961, p. 485, 1978, p. 630) and Witte (1963, p. 449) themselves, after presenting this theory, notice that the empirical evidence goes against it, because the price of most capital goods shows a remarkable constancy over the trade cycle, so there appears to be no upward-sloping supply schedule for capital goods in the short run. Perhaps for this reason, the rising-supply-price theory does not seem currently to enjoy much favour (except that it is somewhat reabsorbed in the adjustment-cost and q theories, as will be made clear below).

It is nonetheless worthwhile to notice other theoretical shortcomings of this derivation of a decreasing investment schedule.

First, the yield of investment is treated as independent of the level of the interest rate, what has been criticised in § 14. Indeed, even accepting - as these authors do - the marginalist notion of 'capital', the variability of the capital-labour ratio on new plants means that that ratio, and therefore the marginal product of 'capital' - i.e. the yield of investment - in new plants, will depend on the rate of interest.

[34] . Asimakopulos (1971, p. 383) attributes this argument to Keynes himself, perhaps on the basis of Keynes's statement that the short-period rising supply price of investment goods is "usually the more important in producing equilibrium in the short run": but, as remembered in the text, Keynes admits that this is a short-period reason only, which tends to disappear in the longer run, so the persistent reason for the decreasing shape of the MEC schedule in Keynes is the decreasing returns to an increasing *supply* of capital goods (for an examination of the Marshallian nature of Keynes's analysis of investment, see Panico, 1988, Ch. 4, Appendix B). Ackley instead accuses Keynes of confusing movements along, and movements of, the MEI schedule(Ackley,1978, p. 630, note 18).

Second, the notion of a downward-sloping long-period demand curve for 'capital' remains central in that it determines - jointly with the level of the interest rate - the desired long-period capital stock inversely related to the rate of interest: the role of the short-period rising supply price of capital goods is only that of determining the speed with which firms adjust their capital stocks to the long-period desired ones. (This also shows that it is implicitly admitted that in the long run there is, on average, the full

employment of labour, otherwise the desired long-period capital stock would be indeterminate.) The capital-theory results therefore are damning for this approach too.

§17. ***Adjustment costs***.

Adjustment costs (Eisner and Strotz (1963), see Söderstrom (1976), Galeotti (1984), Abel (1990) for surveys of the subsequent vast literature) are at present very popular among investment theorists. The basic idea is well known: if the optimal capital stock *of* a firm exceeds its actual capital stock but there are increasing marginal

costs to expansion (a more rapid adjustment is proportionately more costly than a slower adjustment) e.g. because of installation or break-in costs, then the firm will not find it convenient to adjust immediately to the new optimal capital stock and will prefer to spread out its adjustment over time, choosing an optimal adjustment path.

Although I know of no empirical enquiry as to the actual relevance of adjustment costs, the idea of adjustment costs no doubt contains some truth. When e.g. Eisner writes: "costs of planning, ordering, supply, and construction may well be an increasing function of the speed with which they are accomplished" (Eisner 1978, p. 5), he points at elements no doubt relevant in reality, although only over a certain range of the adjustment speed([35]). The problem is, that this idea does not yield an *aggregate* investment function without additional and debatable assumptions.

According to Sargent, the adjustment cost approach is "the most successful attempt to rationalize the Keynesian investment schedule" (Sargent, 1979, p. 127). But

[35] 35. There appears to be in this literature a tendency to include into adjustment costs all costs connected with the modifications of fixed plants and no longer present during the normal operation of the fixed plant once installed. This is a misconception: the normal, inevitable costs of starting an investment, e.g. building costs, costs of training workers to new machinery etc. must be included in the normal costs of production determining long-period prices; adjustment costs can only be the *extra* costs incurred in order to realize an investment faster than at minimum costs, so as to be able to exploit higher-than-normal profit opportunities before these disappear: thus they may be relevant to explaining the speed with which productive investment flows into particularly profitable fields; but they will be a transitory phenomenon only, since further or potential entry of firms adopting the cost-minimizing construction speed will cause price to tend to the normal long-period level defined by the cost-minimizing technology. That such a cost-minimizing construction speed may be presumed to exist is, on the other hand, indubitable, because excessive construction length not only causes technical deterioration of the incomplete plant, but also growing interest costs.

he avoids all discussion of how successful: the plausibility of the assumptions of the adjustment cost school, as well as the various objections which can be advanced against them, are not examined; the Keynesian investment schedule is thus turned into a dogma which cannot be questioned; like God in Scholastic philosophy, we are certain of its existence, the only problem is to discover the right proof.

The possible objections appear on the contrary to be quite strong.

To start with, doubts have been advanced as to the empirical relevance of the assumption that there are generalized positive adjustment costs which not only increase, but also increase at an increasing rate, with the level of investment([36]). But even leaving these doubts aside, there remain grave theoretical problems.

The approach suffers from a fundamental shortcoming, which makes its popularity difficult to understand. Let us remember that the analysis attempts to determine the optimal adjustment path of *an individual firm;* the passage to the *aggregate* investment function is obtained by assuming "that the macro function is simply a 'blown-up' version of the micro function" (Junankar 1972, p. 61; also see *ibid.* p. 43); but this aggregation procedure forgets about *possible variations in the number of firms.* The assumption that investment cannot comprise the setting up of new firms would clearly be illegitimate: reality does show the setting up of new firms. But then one must admit that the positive extraprofits which stimulate existing firms to grow should also stimulate the setting up of new firms. Then the growth rate of the *aggregate* capital stock also depends on the rate of creation of new firms: with completely free entry, because of price-taking the existence of positive profits would imply the entry of an infinite number of firms, i.e. an infinite rate of investment; the only way to avoid this result would be to find something limiting the entry of new firms, but the theory has nothing to say about it. This is partially admitted e.g. by Söderstrom (1976, p. 386), who writes that in adjustment-cost theories of investment "market equilibrium ....may be indeterminate under free entry": where rigour would require replacing "may be" with "is". Thus adjustment costs do not determine the speed of variation of the aggregate capital stock - i.e. do not determine aggregate investment - except under an implausible assumption of a constant number of firms.

This problem can only be surmounted by interpreting the adjustment costs as 'external' adjustment costs due to the rising-supply-price schedule for capital goods([37]), but then 'adjustment costs' is a superfluous misnomer. And anyway the

[36] For more on these doubts, see e.g. Nickell, 1978, pp. 37-39.

[37] . The usual reasoning in this respect, which attempts to keep the analysis at the level of the individual firm, is that the assumption of increasing supply price of capital will be legitimate if the firm is large relative to

criticisms would apply which have been advanced in §16; among them, the necessary dependence on the traditional notion of 'capital'-labour substitution, a dependence which on the contrary is not necessarily there if the theory is more correctly restricted to 'internal' adjustment costs: then even with fixed coefficients, the opening up of profit opportunities due to a decrease of the interest rate (while by assumption prices, including the real wage, do not change) would make expansion profitable, and the existence of increasing adjustment costs would render the rate of expansion finite, and higher the lower the interest rate.

The assumption that as the interest rate varies, the other prices, including the real wage rate, can be assumed unchanged, so that returns (gross of interest payments and of adjustment costs) are unaffected by the level of the interest rate, is also untenable when one passes from the individual firm to the aggregate economy (or even only to the industry). Even if one assumed away price-cutting competition among existing firms the moment there were decreases in costs, there would still be the entry of new firms to quickly cause prices to tend to average costs (cf. the discussion above in connection with the 'array-of-opportunities' approach). Taken literally, adjustment-cost theories deny all influence of variations of the interest rate on the real wage, against all tradition in economic theory.

These criticisms also apply to the original proposal of the adjustment cost approach, by Eisner and Strotz (1963), where it was proposed as a way to justify a non-instantaneous adjustment to the desired capital stock, where the latter was determined *by taking output as given.* In fact the approach**,** if valid, would be capable of determining an investment schedule with no need to take either employment or output as given, and this is probably the main reason for its popularity. Unfortunately, the shortcomings are so serious that the approach appears indefensible.

§18. ***Jorgenson.***

Here Jorgenson's econometric studies will not be discussed, attention will only be given to his more theoretical analyses (Jorgenson 1963, 1967). A detailed exposition of Jorgenson's theory will not be attempted here: the interested reader can consult Precious (1987) for a clear introduction, and Bliss (1975b, pp. 306-309), as well as Ackley (1978, pp. 625 note, 634-8, 640-1), for critical commentaries.

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the industry supplying the specific capital goods it needs (cf. Nickell, 1978, p. 35). This makes the assumption *not* in general legitimate at the firm level even when it is legitimate at the aggregate level. Thus we have here a case where the misconceived attempt to derive an aggregate schedule from the individual firms' partial-equilibrium decisions needs stronger assumptions than are actually necessary

Jorgenson's 1963 article is very different from his 1967 contribution. In the earlier article Jorgenson argues that the rate of interest will determine the desired K/L ratio and hence will determine the desired K, *given the output to be produced.* The desired K is then reached with a (distributed) lag (which is left unexplained). The analysis is formulated for a single firm with constant returns to scale, but, because of its dependence on a given output level, it can easily be re-interpreted as applying to industries, or to the entire economy: in the latter version, it has found its way in simplified form in some macro textbooks, e.g. Dornbusch and Fischer([38]). It is then a neoclassical variation on the flexible accelerator. It is openly based on the notion of 'capital'-labour substitution and therefore subject to the Cambridge criticisms.

The 1967 contribution is something else. Output is no longer taken as given; only prices are. The analysis concerns the investment decision of a single perfectly competitive firm, which, as in the adjustment cost approach, takes as given the current and expected output price p(t), the labour wage w(t), the supply price z(t) of the single investment good, and the discount (interest) rate r(t). But no adjustment costs are introduced (it is also assumed that there is a perfect market for second-hand capital goods), nor is the employment of labour taken as given; in order to determine a finite optimal capital stock $\dot{K}$ (a finite dimension of the firm), Jorgenson must assume (which he does, see 1967, p. 141, without spending one word to justify the assumption) decreasing technological returns to scale. The firm's maximand is

$$\max V(0)=\int_0^{\infty}\{p(t)Q(t)-w(t)L(t)-z(t)I(t)\}e^{-r(t)t}dt$$

s.t. $Q(t)=F(K(t),L(t))$ (with decreasing returns to scale),

$I(t)=\dot{K}(t)+\delta K(t)$.

[38] . Dornbusch and Fischer (1987) are among the least neoclassical of the neoclassical-synthesis authors. Prices are determined by full-cost pricing, or entry-preventing pricing; aggregate demand is determined by the multiplier; the neoclassical conception of capital only enters the analysis when they determine the desired capital stock, which is made to depend on the interest rate's influence on the desired K/L ratio, and on the intended levels of output (i.e. expected levels of sales): the rate of interest (and the associated real wage) selects the KIL proportion on the isoquant corresponding to the intended level of output; the desired capital stock will change if either the rate of interest changes, or planned output (i.e. expected demand), or both. Although a neoclassical influence of the interest rate on investment is thus admitted, the accelerator has an important role to play too; this opens the way (although the book does not make it sufficiently clear) to multiplier-accelerator instabilities, and to questioning many IS-LM-based conclusions (e.g. crowding out). It then suffices to argue that the elasticity of the K/L ratio to the rate of interest is not very great, so that the rate of interest has little influence on investment, and the elements are present for a reconstruction of macroeconomics on a non-neoclassical basis.

where Q is output, p its price, L labour, w its wage, I is physical investment, z the price of capital goods, r the rate of interest, K the capital stock, $\dot{K}$ its variation with respect to time, and 8 the radioactive deterioration rate of the capital stock. (In fact Jorgenson simplifies the analysis by assuming p, w, r to be constant in time.)

The assumption that the amounts employed of capital and labour can be changed costlessly, together with the assumption of instantaneous flow production, implies that, much as in static analysis, the firm will want to adjust its labour force until the marginal product of labour at each instant equals the real wage at that instant:

$$\partial Q/\partial L=F_L=w/p$$

(where the magnitudes refer to the same instant t), and that the firm will desire the capital stock which makes the marginal product of capital equal to the marginal cost of capital; the only complication being the definition of the marginal cost, which must now include not only depreciation but also the possible capital gain or loss on the capital good during the period, due to changes in the selling price of capital goods; this new notion of marginal cost, often called 'user' or 'rental' cost of capital, or opportunity cost of the services of capital, is given by $c=z(r+\delta)-\dot{z}$:

$$\partial Q/\partial K=F_K=c/p=\{z(r+\delta)-\dot{z}\}/p,$$

where, again, all magnitudes refer to the same instant t. Unless the production function exhibits (sufficiently) decreasing returns to scale([39]), these two marginal conditions do not determine a finite profit-maximizing size of the firm and input proportions, and hence do not determine a finite K*.

With these assumptions, Jorgenson proves that K*(t) depends only on the values at the same moment of p(t), w(t), and $c=z(r+\delta)-\dot{z}$ (the thing is evident from the two marginal conditions listed). In order to obtain that K*(t) will change continuously, and thus obtain a finite net investment $\dot{K}^*$, Jorgenson *assumes* that p, w, c are continuous functions of time (in fact he assumes that p, w, r remain constant); as a consequence, K* changes continuously from K*(0) onwards, thus determining desired investment along the optimal path. But, with an arbitrarily given initial capital stock K(0), there is no guarantee that K*(0)=K(0), and then desired investment at t=0 might be infinite; in order to avoid this problem, Jorgenson restricts his analysis to the case K*(0)=K(0), i.e. assumes that the firm is *already*, at time 0, on an optimal path (no justification is

[39]. In fact Jorgenson needs more than simply decreasing returns to scale: if e.g. returns to scale were decreasing but less and less so (tending asymptotically to constant), then a finite optimum might not exist. This is not usually noticed.

given for this assumption either). In order to study the influence of changes in the interest rate upon investment at time 0, one is therefore restricted to comparing optimal paths for all of which K*(0)=K(0), in spite of r(0) being different; the difference in the evolution of K* from t=0 onwards will cause a difference in K* at time 0. Having assumed that p(0), w(0) and z(0) are given, and having further assumed that p, w, r remain the same from moment 0 onwards, Jorgenson finds that the only paths satisfying K*(0)=K(0) are those for which the differences in r(0) are tied to differences in z as follows:

> all changes in the rate of interest are precisely compensated by changes in the rate of change of the price of current and future investment goods so as to leave the own-rate of interest on investment goods unchanged (Jorgenson 1967 p. 148),

the reason being that, since K*(0) depends only on p(0), w(0) and c(0), and since p(0), w(0) and z(0) are given and hence common to all paths, two paths differing as to r(0) and both satisfying K*(0)=K(0) must have the same p(0), w(0), z(0) and c(0); the fact that c(0) must not change as r(0) is made to change to generate alternative paths implies, since $c=z(r+\delta)-\dot{z}$ and z(0) and δ are given, that $r-(\dot{z}/z)$, the own-rate of interest on investment goods, must not change at time 0 as r(0) is changed. Jorgenson then proceeds to *assume* (again, without a word of justif1cation) that this is just the case. He is then able to prove that, for the case $\dot{r}=\dot{w}=\dot{p}=0$, and given w(0) and p(0), as r(0) is made to vary the paths change in such a way that $dK^*(0)/dr<0$, i.e., since gross investment at time zero is simply $I(0)=\dot{K}^*(0)+\delta K(0)$, that investment at time zero is a decreasing function of the interest rate([40]).

Even a neoclassical theoretician should agree that this way of deriving a decreasing investment schedule runs against at least the following grave objections:

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[40] . The reason is that, as r rises at time 0, then $\dot{z}$ rises to compensate so as to leave c(0) constant, but all future c(t)'s are higher, so K*(0) remains the same but all future $\dot{K}^*(t)$ will be lower (because dK*(t)/dc(t) is negative) and hence K*(0) will be lower. That future c(t)'s must be higher can be shown as follows. The price at time s, z(s), of a new investment good purchased at that time, must be equal to the value of all future capital services of that investment good, discounted to time s. Or equivalently, discounting to time 0, one obtains $e^{-rs}z(s)=\int_s e^{-rt}c(t)dt$. Now, obtains. by assumption, as r varies, $\dot{z}$ varies in such a way that the own-rate of interest on investment goods does not vary, i.e. the discounted value of future investment goods remains unchanged as r vanes, $d(e^{-rt}z(t))/dr=0$, so the value of the integral on the right hand side must not change as r varies. If r increases, e^{-rt} decreases so the $c(t)'s$ must increase.

1. the criticism advanced above against the adjustment cost approach, that aggregate investment remains indeterminate because the number of firms cannot be taken as given, applies to Jorgenson's analysis too;

2. the assumption implicit in the analysis, that z may go on increasing for ever in the face of given p, w and r, is incompatible with the accepted view that prices in the long run must equal costs of production;

3. more generally, again as for the adjustment cost school, the assumption that the price of the investment good and the real wage are given independently of the level of the interest rate is indefensible; it implies, among other things, that it may happen that firms earn extraprofits for ever;

4. the assumption of decreasing returns to scale is unjustified;

5. there is no discussion of the mechanism which should ensure that z varies in such a way as to leave r-($\dot{z}$/z) unchanged, nor more generally of whether and when this assumption is plausible, or even only logically possible, what it will generally *not* be: e.g. in a one-good world such as the one of the Solow-Swan neoclassical one-sector growth model, p-z=l necessarily, so $\dot{z}(0)=0$ whatever r(0), and Jorgenson's analysis is logically impossible.

Thus, even from the perspective of the marginalist approach to value, Jorgenson's 1967 theory appears totally indefensible (and is so judged e.g. by Tobin in his Commentary on Jorgenson's article in the same volume).

§19. ***Tobin's q***.

Tobin's approach (Tobin, 1969, 1980, 1982; Tobin and Brainard, 1977) argues that investment is a positive function of the ratio q between the market value of the capital assets of a firm and their replacement cost, and in particular that net investment will generally be positive or negative according as q is greater or less than 1. It is specified (Tobin and Brainard 1977, p. 243) that one should calculate these magnitudes at the margin. The numerator will then be greater than the denominator if the internal rate of return on the stream of net returns expected from additional capital goods is higher than the interest rate, i.e., in Keynesian terminology, if the marginal efficiency of capital is higher than the interest rate. This theory argues therefore that investment will be positive if the marginal efficiency of capital is greater than the interest rate, and more specifically that investment will be an increasing function of the difference between the two. The obvious difference from Keynes is that Keynes argued that investment would be pushed to the point where the marginal efficiency of capital *equals* the interest rate; Tobin's theory adds to Keynes's theory a sluggish

adjustment of the investment level, which is justified in terms of adjustment costs and/or short-period rising supply price of investment goods ([41]).

Recently, it has been shown that in fact the adjustment costs approach might be re-interpreted in terms of Tobin's *q* (Hayashi 1982, Galeotti 1984). But Tobin's *q* theory is more general than the adjustment cost theory, because of the variety of reasons which might cause *q* to differ from 1 and to influence investment. Its rather vague justification is, paradoxically, an advantage in that one can put behind it more plausible mechanisms. For instance, entry of new firms does not undermine the theory because Tobin includes a short-period rising supply price or delivery lags among the causes of the non-instantaneous tendency of marginal *q* to 1.

Still, from a theoretical point of view, on why aggregate investment may be taken to be a decreasing function of the rate of interest, Tobin's q appears to add nothing new to the other explanations relying on an optimal capital stock determined by long-period capital-labour substitution (with the full employment of labour), and then on short-period rising supply price or on adjustment costs to explain the sluggish adjustment to the optimal capital stock([42]). Nor should this conclusion be surprising,

[41] "Investment would not be related to q if instantaneous arbitrage could produce such floods of new capital goods as to keep market values and replacement costs continuously in line..such arbitrage does not occur. Discrepancies between q and its normal value do arise The speed with which investment eliminates such discrepancies depends on the costs of adjustment and growth for individual enterprises, and for the economy as a whole on the short-run marginal costs of producing investment goods" (Tobin and Brainard 1977, p. 244). Notice that the last lines of this sentence appear to imply that the replacement cost at the denominator of q is measured by Tobin and Brainard at *long-period* normal prices. Tobin and Brainard argue that even Keynes really agreed with their theory: "Since Keynes discusses at length independent variations in the marginal efficiency of capital and the rate of interest, he does not really imagine that investment adjusts the capital stock fast enough to keep them continuously equal. Indeed the true message is that investment is related to discrepancies between the marginal efficiency and the interest rate" (ibid.). But this opinion of theirs derives from their definition of the marginal efficiency of capital as a long-period notion, i.e. as not incorporating a rising-supply-price-of-capital-goods hypothesis. They appear to think that Keynes's notion of the marginal efficiency of capital coincides with the marginal product of capital at long-period normal prices: "Keynes' condition that the marginal efficiency of capital equal the rate of interest determines not the flow of investment but the stock of capital" (*ibid.*). Thus, apart from the added consideration of 'internal' adjustment costs, Tobin's theory of the determinants of investment appears to be very close to Lerner's.

[42] Tobin's contribution appears to consist in having added the suggestion that the stock market valuation of firms may, with caution, be used to infer the current evaluation of the present value of expected future returns. But it seems not to have been generally noticed that Tobin's q will also reflect - if stock markets reflect 'fundamentals' - the degree of utilization of capacity: if, on the average, capacity utilization is below normal and expected to remain below normal for some not inconsiderable time, at the given interest rate the capitalized flow of returns will be less than the replacement value of existing plants, it will in fact approximately equal the value of the plants necessary to produce the current output at a normal rate of utilization (because empirical evidence strongly suggests that relative prices remain close to the long-period ones associated with a given rate of interest even when most firms operate below normal capacity). An empirical finding of a positive correlation between Tobin's q and aggregate investment would therefore be no proof that the rate of interest has a negative influence

given Tobin's notoriously unproblematic acceptance of the marginalist theory of value and distribution and of the notion of 'capital' as a single factor, even of the aggregate production function. But then the criticisms advanced against those explanations also apply to any attempt to use Tobin's *q* in order to defend the traditional investment schedule.

Conclusions and perspectives.

§20.

One may conclude that the more recent justifications of the view of aggregate investment as a decreasing function of the interest rate either ultimately rely on the traditional marginalist notion of a demand for 'capital' inversely related to the interest rate, or are theoretically indefensible even apart from the criticisms of marginalist/neoclassical capital theory, or both. In particular, again and again in the analyses elaborated after Keynes the mistake recurs, of treating the yields from investment projects as independent of the level of the interest rate a mistake pointed out not only by the 'Sraffian' critics but also by the more attentive mainstream theorists, e.g. by Ackley (1978) and Alchian (1955).

Thus at present there is no defensible theoretical justification of the standard view of investment as a regularly decreasing function of the interest rate.

That a significant negative elasticity of investment with respect to the interest rate may not be easy to confirm empirically is then no longer a puzzle: there simply is no theoretical reason why it should be observed([43]).

on aggregate investment: it might simply reflect the influence on investment of the average degree of utilization of capacity, i.e. of the accelerator.

[43] . That some negative influence of the interest rate on investment may be sometimes detected by empirical studies does not anyway appear surprising to the non-neoclassical theorist. There are several non-neoclassical indirect routes through which such an influence might operate; but their working is not guaranteed, and there are also routes through which the influence might be of opposite sign, so that no general and unambiguous conclusion, independent of the specificities of the situation, appears derivable. E.g. a lower interest rate in a single nation may cause outflows of financial capitals which cause a devaluation which stimulates exports and thus, through the accelerator, stimulates investment; or, with a fixed exchange rate, the lower interest rate, by decreasing production costs in that nation relative to other nations (just like a decrease in real wages), may lower the price level or slow down its rate of increase and thus increase the nation's competitiveness and again stimulate exports and thus investment; on the other side, the lower-than-abroad rate of return on investment, associated with the lower product prices, or higher import prices, may well for some time discourage, rather than encourage, investment (Chirinko, in the quoted survey of investment theory, cites econometric evidence giving some support to the thesis that a higher rate of return on capital has a positive

The implications for macroeconomic theory are enormous. The interest rate cannot be seen as the price bringing investment into equality with savings. Say's Law the thesis that investment adapts to savings - loses its foundation. The faith in the spontaneous tendency of market economies to the full employment of resources must therefore be abandoned, not only because the capital-theory results imply that there can be no presumption of a downward-sloping demand curve for labour, but also because there can be no presumption that aggregate demand will spontaneously rise to equal full-employment output. And it has been argued in Part I that neo-Walrasian equilibrium theory can offer no help against these conclusions, because it is unable to tell us anything at all as to how real economies work.

§21.

It is then natural to turn again to Keynes's principle of effective demand, i.e. to the thesis that it is variations in income which bring about the equality between savings and investment (or more generally between aggregate income and aggregate demand).

Let me here briefly digress on one possible reason why this return to a decidedly Keynesian approach is resisted. The belief is widespread that, if individuals are selfish maximisers, then it is difficult to reconcile the implication for the labour market of a Keynesian approach - that unemployment is generally involuntary - with the downward-rigidity of money wages. Indeed, much recent theoretical effort (e.g. efficiency wages) has gone precisely into trying to explain why wage rigidity in the presence of unemployment might not contradict the rationality hypothesis. The greatest part of this effort, however, has been motivated by the acceptance of Say's Law (investment adapts to savings) and of the decreasing demand curve for labour premises which oblige one to find in the rigidity of wages the explanation for persistent unemployment([44]). If, on the basis of what has been argued or for any other

influence on investment, i.e. that a lower rate of return, such as will be presumably associated with a lower rate of interest, has a negative influence on investment). Or the lower interest rate, by being associated with a redistribution of income away from property incomes toward labour incomes, may induce an increase in the average propensity to consume, and thus in the multiplier, and thus again stimulate investment through the accelerator; on the other side, the increase in consumption may induce the business community to expect restrictive government policies because of balance-of-payment constraints or fears of inflation, and thus it may discourage investment. The traditionally assumed negative influence of the rate of interest on inventories is also, it would seem, not easy to confirm empirically; it would, anyway, be a transitory influence only.

[44] . Keynes's line of defense - that decreases of money wages would not translate into lower real wages if aggregate demand, by not increasing, caused the price level to decrease in step with money wages - was found weak by the 'neoclassical synthesis' theorists, because on the basis of Keynes's own analysis of the determinants of the rate of interest and of investment, it could be argued that the lower price level brough about by the lower money wages, by entailing a lower transaction demand for money, would sooner or later bring about a lower rate

reason, one drops those premises, the puzzle of wage rigidity in the face of persistent unemployment appears to lose its mysterious character. This is because one must then abandon the presumption of a significant negative elasticity of employment with respect to the real wage. But if the level of employment is not significantly improved by real wage decreases, then it is only to be expected that historical experience will have taught workers that wage competition must be avoided. If the unemployed workers offer to work for less than the current wage, it suffices that the employed workers themselves accept the lower wage, and they will not be *replaced* with the unemployed, since labour turnover does imply at least some minimal costs. (Indeed, in the neoclassical argument, it is the increased demand for labour which will ensure that the lower wage gets the unemployed a job, not their ability to get hired in *place of* previously employed workers.) But if the resulting lower real wage does not increase employment, the unemployed workers have gained nothing by offering themselves at a lower wage - they are still unemployed, and have only made the employed workers worse off (and themselves too, in so far as they receive support from the income of their employed relatives). No wonder, then, that popular culture should have developed a variety of ways ('fair wage' notions etc.) to spare new entrants into the reserve army of the unemployed the need to learn through experience - a learning process which would greatly damage their fellow workers in the meanwhile - that wage competition brings no advantage to the unemployed even from a strictly selfish viewpoint. (Cf., for similar viewpoints, Garegnani, 1990b, p. 121**;** De Francesco, 1993) The assumption, that - at least, if one leaves efficiency wages aside - if the labour market is competitive wages should indefinitely decrease so long as there is involuntary unemployment, appears therefore to be only justified if one accepts the neoclassical belief in a significant elasticity of employment with respect to the real wage (No wonder, then, that one does not find such an assumption in the classical economists from Adam Smith to Ricardo and Marx, who did not entertain the notion of a decreasing demand curve for labour.)

There appears therefore to be little obstacle to going back to the principle of effective demand, and this not only for the short run, but also for the long run, since once this approach is freed from the traditional marginalist elements with which it is combined in Keynes (the decreasing demand for labour, and the decreasing

of interest and thus a higher investment level and thus a higher aggregate demand. This traditional rebuttal of Keynes's argument rests on the view of investment which has been argued to be untenable in the present paper. The rejection of the traditional marginalist notion of 'capital', by undermining the decreasing labour demand schedule as well, also shows that Keynes did not need to demonstrate that lower money wages would not translate into lower real wages, in order to argue that lower money wages would not bring about a greater demand for labour.

investment schedule) - there can be no presumption that in the long run the economy will gravitate around a full employment path. The reconciliation will finally be easy between economic theory and historical episodes such as the Great Crisis of the 1930s, or the world recession after 1973.

The task facing investment theory nowadays appears therefore to be, to discriminate between the several competing alternative non-neoclassical explanations of investment. It is not the purpose of the present paper to start on this task. There can be little doubt anyway that desired capacity will be confirmed to be a main determinant of investment Innovations also cannot but be another fundamental influence. The role of profits (which are seen, by many economists influenced by Kalecki, as supplying investible funds which slacken the financial constraint on firms) is on the contrary an open question: Kalecki's argument, in so far as it is not the accelerator under a different garb, is not very solid theoretically, and the empirical evidence is ambiguous([45]); and Kaldor's argument, that a redistribution against wages decreases aggregate demand, suggests that a higher rate of profit may easily end up by damaging, rather than aiding, investment (an argument also in Marx). Probably it will be difficult to find a simple theory of aggregate investment, which will make it depend on a few variables only. For instance, the influence of governments' direct intervention and/or (overt or covert) supportive stance vis-à-vis private investments is probably extremely important, and I would guess it can explain a considerable part of the observed differences in the growth rates of nations. Historical research and attention to the specificities of each nation and period will therefore have to integrate theoretical and econometric research.

[45] . Cf. Petri, 1993b; Yoshikawa, 1996, ch. 7, pp. 260-261

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