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Neglected implications of neoclassical capital-labour substitution for investment theory: another criticism of Say's Law

Abstract

Neoclassical capital-labour substitution correctly understood is unable to prove a tendency toward the full employment of resources because it leaves investment indeterminate if the full employment of labour is not assumed to start with; then Say's Law loses plausibility because of the inevitable presence of accelerator-type influences on investment, even neglecting the inconsistencies of neoclassical capital theory; and wage decreases cause a decrease of investment, undermining the 'neoclassical synthesis' criticism of Keynes. The way a negatively interest-elastic investment function is obtained by Romer without assuming the full employment of labour, that is through adjustment costs, relies on several grave mistakes. The recent DSGE models which directly assume that investment equals savings are not supported by general equilibrium theory because the latter theory is admitted by the specialists not to be a positive theory, nor can those models rely on the neoclassical synthesis or monetarism because of the critique of this paper (besides the capital critique), so they must be discarded too.

JEL classification: E2, B5

§1. Introduction. Difference between this argument and the capital-theoretic criticism.

This paper presents a new argument against Say's Law, that is, against the thesis accepted in most current mainstream macroeconomics that investment adjusts to savings [1] and therefore aggregate demand poses no obstacle to the selling (at cost-covering prices) of the aggregate supply of goods whatever the forces determining the latter. This thesis, I will argue, is untenable *even if* one does not criticize the neoclassical conception of capital-labour substitution as done in the Cambridge controversies in capital theory; nor need one have recourse to Shacklean uncertainty or Robinsonian animal spirits or 'malfunctioning' of financial intermediaries.

Perhaps surprising readers familiar with my previous writings, in the present paper I do not rely upon reswitching and reverse capital deepening in order to criticize Say's Law. But this does not in the least imply a rejection of the criticism of neoclassical theory that emerged from the Cambridge capital-theory debates, and that I tried to clarify in Petri (2004). At the most, my present argument may suggest that the strength of the Cambridge criticism induced too little attention to a further weakness of the neoclassical argument in support of Say's Law.

Let me anticipate where this paper's criticism of the neoclassical argument departs from the capital-theoretic criticism. The latter proceeds as follows: the neoclassical argument in favour of Say's Law rests on a presumed capacity of the rate of interest to bring investment into equilibrium

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[1] Of course I am not denying the possibility of a mutual influence (e.g. the propensity to save might depend on the rate of interest); but the basic idea of the theories I intend to criticize is that the aggregate amount of saving may well be given independently of investment, and then investment will adjust to it, while the converse (given investment, and savings adjusting to it) does not happen; to insist on mutual determination misses this fundamental asymmetry.

with savings, owing to a negative interest elasticity of investment. This negative elasticity is derived from a decreasing demand schedule for (value) capital, which like all neoclassical factor demand schedules is based on the direct and indirect substitution mechanisms and on the full employment of the other factors. The criticism based on reverse capital deepening argues that, since it has been shown that the normal demand for capital the single value factor *per unit of labour* need not be a regularly decreasing function of the rate of interest and can be potentially of nearly any shape (this shape also depending on the choice of numéraire), it follows that the demand schedule for capital, based on a given (i.e. full) employment of labour, can analogously be of nearly any shape, and therefore the same holds for the investment function. As argued particularly forcefully by the late Pierangelo Garegnani (1964-5, 1978-9, 1983, 1990), this refutation undermines the 'neoclassical synthesis' objection to Keynes, that if money wages decrease in the presence of unemployment the demand for labour will rise owing to the so-called 'Keynes effect': the consequent decrease of the price level, hence of the demand for money, hence of the rate of interest, will raise investment. Reverse capital deepening causes the last step in this argument to fall down. In Petri (2004, ch. 7) I reinforced Garegnani's contention by showing that the attempts, after Keynes, to derive a negative interest elasticity of investment without relying on the traditional neoclassical conception of capital-labour substitution are all indefensible [2] . Now, this 'Sraffian' criticism *implicitly concedes* that, if the demand for capital were a regularly decreasing and sufficiently elastic function of the rate of interest, the tendency toward the full employment of labour (as long as money wages decrease in response to unemployment) would be a *prima facie* defensible thesis, because the 'neoclassical synthesis' anti-Keynesian argument would acquire some credibility (at least, as long as 'animal spirits' or 'liquidity traps' were not brought in to keep at bay the force based on the 'Keynes effect' which, if not impeded, would push investment toward equality with full-employment savings). My central point in the present paper is that *this implicit concession should not be made*, because *even* traditional neoclassical capital/labour substitution is unable to support the 'neoclassical synthesis' argument, and the reason is that the derivation of a well-defined investment schedule from the working of neoclassical capital-labour substitution *requires* the full employment of labour, but multiplier theory shows that labour employment depends on investment and therefore cannot be taken as given when deriving the investment function. It is legitimate to base the demand-for-capital schedule on the full employment of labour because this is how factor demand schedules are derived in the neoclassical approach, but whether these schedules really indicate the demand for a factor is a separate question that requires assessing the legitimacy of assuming that the other factors are indeed fully employed; now, the demand for capital is different from the demand for labour or land, in that it can only manifest itself – as I will illustrate – as a sequence of investment demands which affect aggregate demand and hence labour employment; as a result, a correct understanding of how, according to neoclassical theory itself, capital-labour substitution concretely operates shows that the rate of interest leaves investment *indeterminate* even accepting the neoclassical conception of capital-labour substitution, an indeterminacy only surmountable through an *assumption* of continuous full employment of labour that the theory is unable to justify. Once the full employment of labour is not

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[2] Then in Petri (2011) I showed the weakness of the attempts to argue that the occurrence of reswitching and reverse capital deepening is so unlikely that one can assume that they do not occur.

assumed to start with (and it cannot be taken for granted as a starting point of the analysis, it can only be, if at all, a *result* of the analysis), the influence of the rate of interest upon capital-labour substitution and investment must be analyzed in a different way and has very troublesome implications for Say's Law. The argument expands upon an observation made in Petri (2011, pp. 409-410); the point was very briefly hinted at already in Petri (2004, p. 259-60, 301) but at the time I was not fully conscious of its implications. Here I present the point in the detail it deserves, and draw its implications for macroeconomic theory.

The argument comes out to support Keynes's claim that in the marginalist theory he was intent on criticizing [3] the full employment of labour was an *additional* assumption not derivable from the mechanisms of factor substitution at the foundation of that theory. The reply of the 'neoclassical synthesis' was that Keynes was mistaken (if money wages were flexible), because of the 'Keynes effect' remembered above. It will be seen that my argument implies that Keynes was actually right, although not for the reasons he advanced, but rather because of the implication for investment of the possibility of labour unemployment within an otherwise neoclassical framework, an implication that escaped him. Without the continuous full employment of labour, the rate of interest can only determine the desired *ratio* of capital to labour, which leaves the capital to be invested in new plants indeterminate until one determines the desired capital stock – which requires looking at desired productive capacity and hence at expected demand and its variations. As I will remember, some neoclassical economists (Jorgenson, and Dornbusch and Fischer) admitted this, but did not see that then extremely serious problems arise for the 'neoclassical synthesis' argument: the capacity of wage flexibility to bring about the full employment of labour disappears. This paper therefore presents a criticism of Say's Law *additional* to the one based on the capital critique.

My argument allows a classification of mainstream approaches to investment into two groups. The first group admits the possibility of labour unemployment in the short run, uses the IS-LM apparatus where the IS schedule is based on a negatively interest-elastic investment function, and then encounters the difficulty of an indeterminate marginal product of capital if labour employment is variable, and to justify the needed investment function has recourse to unacceptable assumptions or plain contradictions. These inconsistencies, criticized in Petri (2004, ch. 7), are still present in recent introductions to investment theory, so I renew here the attempt to correct the situation, this time through a detailed criticism of Romer's advanced macro textbook (2001); I highlight the untenable assumptions – a colossal miseducation of students – Romer must have recourse to in order to derive a negatively interest elastic investment function. The second group, that includes the rational expectations models, the real business cycle models, and the New-Keynesian Dynamic Stochastic General Equilibrium models, *takes it for granted* that investment adjusts to savings; I argue that this assumption cannot be justified on the basis of an appeal to general equilibrium theory, and actually derives from a renewed faith in the tendency toward full employment, a faith having its roots in the success of monetarism and then of rational expectations in the 1970s; this faith cannot but rest on the time-consuming adjustment mechanisms of the

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[3] He called it 'classical', not distinguishing between Ricardo, and the marginalist authors he actually intended to criticize. Nowadays we know that marginalist theory (the term 'neoclassical' is the more common one nowadays but is as misleading as 'classical') is, if anything, anti-classical.

'neoclassical synthesis', undermined not only by the capital-theoretic criticism but also by my criticism, which is therefore also a criticism of the second group of models, that for brevity I will group under the term 'DSGE models'.

§2. Capital and investment in traditional neoclassical theory.

Keynes considered investment a function of the rate of interest *only*, and his approach has dominated macroeconomics afterwards. Nowadays, if a theory of aggregate investment is present in a mainstream macroeconomics textbook (it may be missing – because the economy is assumed to be always on a full-employment intertemporal equilibrium path; a recent example is Wickens, 2008), even when some other influence on investment is admitted (e.g. of income) it is seen as *additional* to the influence of the rate of interest, in the sense that the latter would suffice to determine investment if the other influences were very weak or absent.

It does not seem possible to follow Keynes on this. The justification in Keynes of this influence of the rate of interest upon investment is clearly connected with the notion of a decreasing demand curve for capital; it will suffice here to remember that he wrote

> 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, 1937, p. 178).

The 'classical writers' referred to here are Marshall, Cassel, Carver, Flux, Taussig, Walras, and elsewhere Irving Fisher, but in this way Keynes was putting together rather different derivations of a negative interest elasticity of investment. In two of them, Walras and Fisher, an explicit notion of capital as a single factor of production, an amount of value of variable 'form', is absent, and the investment function is not derived from a 'demand curve for capital' requiring the full employment of labour and therefore useless for an economy where labour employment is still to be determined; however, as I proceed briefly to show, their analyses are patently unacceptable (and recognized as such by mainstream theorists), leaving the derivation of investment from the 'demand curve for capital' as the only neoclassical approach worth detailed discussion.

Walras and Irving Fisher have in common that their derivation of a negative interest-elasticity of investment rests on an assumption of prospective yields of investment independent of the rate of interest, which is clearly unacceptable. In Walras future rentals of capital goods are treated as independent of the rate of interest, so the demand price of new capital goods (the discounted value of the given future rentals) rises when the rate of interest decreases, and this stimulates their production; but these given future rentals are an obviously indefensible assumption since the interest rate is one of the distributive variables that contributes to the determination of normal prices, and its changes alter the rentals of all other factors and in particular the rate of return firms will need to earn on the capital advanced. For example if corn is produced by corn and labour with fixed technical coefficients, and the money wage is given, a reduction of the interest rate, by making firms content with a lower rate of return on advanced capital, will induce competitive firms to undercut competitors by reducing the corn money price and thus the rate of return on investment, with a

resulting rise of the real wage rate[4]. A strictly similar inconsistency of treating relative prices and hence rates of return on investment as independent of the interest rate has been acknowledged with reference to Irving Fisher, who assumes for each saver/investor a given series of alternative income streams among which the investor chooses – for each rate of interest – the ones with the highest present value; these income streams are treated as given independently of the rate of interest, so that Armen Alchian (1955, p. 942), certainly not an anti-neoclassical economist, could write that Fisher's "exposition … is based on the supposition that one merely changes the rate of interest and holds other prices fixed", and accused such a procedure of logical inconsistency [5] . The modern version of this type of approach was named by J. G. Witte (1963) the 'array-of-opportunities' approach: each investor is assumed to face a series of investment projects each offering a given rate of return, and all the projects with a rate of return not lower than the rate of interest are adopted. Gardner Ackley (1978, pp. 622-5), after noticing that this "incorrect derivation of the classical investment function is found in a number of the best textbooks", shows that the approach is indefensible because owing to competition rates of return move in step with the rate of interest, and furthermore because it is unclear why, for the single price-taking firm or for new entrants, replication of any investment project yielding a rate of return higher than the rate of interest should not be possible [6] . Ackley concludes that if a decrease of the rate of interest is to increase investment, it can only be "by selectively favoring the production of more capital-intensive products as opposed to labor- or land-intensive products" and "by favoring more capital intensive methods of production as opposed to less capital-intensive ones" (Ackley 1978, p. 620), a clear indication of the two factor-substitution mechanisms – the one derived from consumer choices and the one derived from technical choices – at the foundation of the decreasing demand curve for capital (mechanisms, it may be noticed, based precisely on the adaptation of relative prices to changes in production costs due to changes in income distribution). It is only from capital-labour substitution that the neoclassical approach can derive the negatively interest-elastic investment function. But this derivation requires an *assumption* of full labour employment.

   To see why, let us remember this derivation in greater detail. The connection—often only implicit—between investment and demand for capital in J. B. Clark, Böhm-Bawerk, Wicksell, Marshall, Knight etcetera has been described by Garegnani with a clarity that can hardly be surpassed (Garegnani, 1983: 34-37; 1990: 59-60). Investment was seen by these authors as the *flow* corresponding to the *stock* demand for capital, given that capital wears out and therefore needs a

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4 If existing firms don't, it will be new firms – whose birth will be stimulated by the persistence of prices higher than average costs – that will lower product prices to gain market shares.

5 Alchian is quoted by Jorgenson (1967, p. 252). Tobin (1987, p. 167) equivalently states that Fisher reasons "as if there were just one aggregate commodity to be produced and consumed at different dates". Actually Irving Fisher admits in one place that changes in the rate of interest alter relative prices, but he dismisses the need for further discussion of the issue by writing that this influence is "a factor which, after all, is more intricate than important" (*The rate of interest*, 1907, p. 168), a statement for which no support is supplied.

6 I strongly recommend the entire chapter 18 of Ackley (1978). Also cf. Petri (2004, p. 264) for similar criticisms advanced by Witte and Kaldor.

continuous flow of new capital goods for its stock to remain equal to the demand for it.

... the demand and supply functions for capital (the stock) envisaged in those theories were supposed to operate over time through a sequence of demand functions for gross investment, and supply functions for gross savings (the flows). To see this ultimate intended equivalence between demand and supply for 'capital' on the one hand, and demand and supply for savings on the other, it is sufficient to assume that production takes place in annual cycles and that all capital is circulating capital. If the wage-rate and product-prices are assumed to adjust without appreciable delay to the equilibrium compatible with the new rate of interest ... the demand function for investment at the end of each year will simply be the demand function for 'capital' as a stock. When there is fixed capital, the analogous relation between demand for investment and demand for capital would be less simple but, in principle, it would be no less strict. (Garegnani 1990 p. 59).

Suppose, for example, that all capital goods last for 10 years, being of constant efficiency throughout their lives and that the initial capital stock is of a uniform age structure. Each year, therefore, 1/10 of the initial physical capital can be replaced in the most appropriate form, and in 10 years the replacement cycle will be completed. If the initial prices were equilibrium prices and if conditions remain unchanged, the entrepreneurs will demand each year capital goods identical to those which have been used up during the year. At the interest rate prevailing in the initial situation, there will thus be an annual demand for investment equal in value to a given fraction (lying between 1/10 and 1/5 and depending on the interest rate) of the value shown by the demand for capital function at that interest rate. If the supply of gross savings is equal to that value of investment, the equilibrium will be maintained. Suppose now that – the supplies of the other factors, technical conditions and consumers' tastes all being unchanged – the rate of interest falls and the wage rate and product prices adapt without appreciable delay to the equilibrium compatible with the new rate of interest. The entrepreneurs will then have an incentive to employ the 1/10 of the workers ('freed' each year by the using up of the physical capital) with the techniques and in the industries which are most profitable at the new rate of interest; they will thus demand each year capital goods with a value equal to a given fraction, slightly greater than the previous fraction, of the value shown by the demand for capital function at the new rate of interest. Because of the form which the theory attributes to that function, the demand for investment will thus be greater that it was at the previous level of the rate of interest and will be able to absorb a greater volume of savings. By considering other possible levels of the rate of interest, one could thus define an investment demand schedule. It would no longer be identical to the demand curve for capital as it was in the case of circulating capital; it would nevertheless be a scale copy of it – but for the effect of the rate of interest on the fraction of the value of the total stock which is represented by the value of the yearly replacement – and would indeed reproduce its fundamental property of elasticity with respect to the rate of interest. (Garegnani 1978 p. 352)

The traditional theory implies that the delayed adjustments in the wages, rents, and prices of products do not fundamentally alter the terms of the question ... Hence the significance of the demand and supply functions for capital as a stock, which would exhibit the basic tendencies destined to emerge from the multiplicity of forces acting at any given moment in the savings investment market. ...
... the traditional analyses of the demand and supply for capital were in effect intended to be an analysis of the demand and supply for savings, abstracting from the complications likely to operate at

each particular moment of time in the savings-investment market. (Garegnani 1990 pp. 59-60).

Traditional marginalist authors had to admit of course that in a concrete economy any adjustment to a change in the data of equilibrium (e.g. labour immigration, or technical progress, or changes in the propensity to save) would also present the 'complications' Garegnani mentions, 'complications' due e.g. to differences in the age structure of fixed capital and connected irregularities of need for replacement of scrapped plants, redistributions of purchasing power among social groups due to changes in the interest rate, possible interference of financial intermediaries, possible convenience of anticipated scrapping of fixed plants, mistaken expectations, slowness in adjustments of factor rentals, and so on; the effects of these 'complications' were to be studied if necessary at a second level of approximation; the demand-for-capital curve was believed to supply "the basic tendencies", the ones emerging once the irregularities of the behaviour of prices owing to accidental or transitory disequilibrium phenomena had time to be sufficiently compensated or corrected, and therefore product and factor prices had become sufficiently close on average to their new normal levels, a process enforced by competition as illustrated above.

It is opportune to stress the working of the economy implicit in the usefulness attributed to such a *long-period investment function*, as I call the investment function generated by such an approach. The demand for capital is determined as the persistent demand for capital goods – aggregated in value terms – implied by the persistent demand for a given net product; this net product being the one produced when labour is fully employed; production methods, output composition and prices being the normal ones associated with the income distribution determined by the full-employment marginal products of labour and capital (following general practice, I assume land is free, because land is not important for the issues to be discussed). But at each given moment the endowment of 'capital' is crystallized in specific capital goods adapted to a specific productive method, so a change (induced by a change in income distribution) in the desired i.e. normal capital-labour ratio in an industry can only be realized by replacement of the old durable capital goods with new ones of a different type, or for brevity, can only be realized in new plants (only in new plants can the marginal productivity of capital be determined, since only there the normal K/L ratio can be varied); if industry output is unchanged, the new plants will only be built to replace the older plants that reach the end of their economic life and are scrapped, the less old plants continuing in operation as long as they earn nonnegative residual quasi-rents. Changes in the output of an industry, whether due to changes in consumer choices or to changes in production methods in firms using that output as an input, will mostly be accommodated, in the short period, by changes in the degree of utilization of existing plants, but if perceived as persistent will induce a desire to change productive capacity, and this will be the other main influence on gross investment (per unit of labour employed in new plants), affecting its composition through the desired composition of new capacity. The composition effect due to change of methods is part, in the traditional marginalist approach, of the overall operation of the so-called direct factor substitution mechanism, which changes the desired K/L ratio in the subsystem producing a given final good; the composition effect due to changes in consumer choice constitutes the indirect factor substitution mechanism. In either case, since in most cases a utilization is impossible of existing productive capacity for the production of goods different from those for which that capacity had been planned, generally the change in industry capacity can only be realized

through the building of new plants in the industries where demand expands, and non-renewal of the scrapped older plants where demand contracts. Thus both the direct and the indirect substitution mechanism between capital and labour can only operate by affecting the type and sector allocation of the *new* durable capital goods to be combined with the flow of labour gradually released by the scrapping of the durable capital goods that reach the end of their economic life. It is only through the replacement of the existing capital goods with capital goods adapted to produce different goods or adapted to a different technical method, i.e. it is only through a change of the 'form' of capital, that the average economy-wide capital-labour proportion can change and a sufficiently elastic demand curve for factors can be obtained[7].

An implication of this view is that the process of change of the 'form' of capital brought about by a change in the rate of interest will take – in order to operate completely – the many years required for renewal of the entire stock of fixed plants of the economy: much longer, generally, than necessary for the new rate of interest to determine a gravitation to the new normal relative prices, a gravitation that only requires that the first plants built according to the new optimal factor proportions be capable of imposing a price equal to their lower average cost, obliging the older plants to accept that price and be content with residual quasi-rents. But economic conditions will seldom remain unchanged for a number of years great enough for complete adaptation of *all* plants to an unchanging rate of interest; therefore it is implicit in this approach that in any concrete economy the rate of interest must be seen as determined, not so as to equalize the capital-labour ratio in factor demand to the ratio of the existing *total* endowment of capital to *total* labour supply, but rather so as to equalize the desired average ratio of capital to labour *in new plants* to the ratio between the flow of 'free' capital (savings) and the flow of labour 'freed' or 'released' by the gradual shutting down of old plants, a ratio that would coincide with the 'total' one only when and if the *entire* labour force were employed in plants embodying methods optimal for that income distribution, and generating productive capacities adapted to the composition of consumer demand. But since most gross investment would be generally motivated by unaltered replacement of used-up circulating and fixed capital, the implicit view of traditional marginalist economists was that the demand-for-capital schedule and its shifts would give a sufficient indication of the tendencies of the investment function. Any nonnegligible difference of actual investment from the long-period investment function would

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[7] This was clear to traditional marginalist authors, for example it was the reason why Hicks (1932, pp. 18-21) expressed strong doubts on the meaningfulness of a *short-period* demand curve for labour, and considered the notion of a demand curve for labour to be meaningful only if one allowed the 'form' of the given capital endowment of the economy to have the time to adapt to the changed real wage. George Stigler (1952, p. 116) repeated the argument of Robertson (1931) and Hicks that capital needs to change 'form' in order for the marginal product of labour to be determinable: he used the Cassel-Robertson example of 10 workers with 10 spades and 11 workers with 11 *smaller* spades to make the point, making it clear that the 'amount' of capital kept constant in this example was a *value* magnitude. Many years later Hicks insisted again on the little variability of labour employment unless capital was allowed to change 'form', by admitting that in the *Value and Capital* temporary-equilibrium approach output and labour employment were initially very rigidly determined, owing to their dependence on work-in-progress already in the pipelines when equilibrium is reached on the 'Monday' of the 'week' (Petri 1991, p. 283; cf. also p. 272).

be part of those transitional or irregular 'complications' mentioned by Garegnani[8]. The most important aspect of the long-period investment function, its negative interest elasticity, could anyway be argued certainly to hold for the actual investment function too, since the *K/L* ratio employed on average in new plants would certainly tend to decrease with rises of the interest rate, while the flow of gradually 'freed' labour as well as the speed of completion of changes in industry dimensions would hardly increase.

3. A model to give concreteness to the need for a full-employment assumption.

It should now be clear that the long-period investment function crucially depends on the assumption of full employment of labour. If for simplicity we assume 'investment' *I* to indicate only the part of total investment whose ratio to labour and to output will respond to changes in distribution, that is, to consist only of gross investment going to new plants[9], and if *L^* stands for the flow of labour employed in new plants, the optimal *K/L* ratio determined by the rate of interest determines *I/L^*, but *I* remains indeterminate unless *L^* at the denominator is given. The long-period investment function assumes *L^* to correspond to the flow of labour gradually 'freed' by the closing-down of the oldest plants in a situation of continuous full employment of labour. It is this given *L^* that allows the *K/L* ratio corresponding to the given rate of interest to determine investment.

If the possibility of labour unemployment is admitted, then a given average *K/L* ratio in new plants does not suffice to determine investment, because new plants can employ less, or (if there already is some unemployment) more, labour than the flow 'released' by the closure of old plants, correspondingly gradually reducing or increasing employment. A given rate of interest, without some assumption fixing *L^*, leaves investment indeterminate.

A very simple model, that stresses only the direct factor substitution mechanism, can give concreteness to the above considerations. Assume an economy where a single good is produced by labour and putty-clay capital; production within each period adapts to the demand forthcoming in that period (the analysis is in discrete time); the output can be consumed, or it can be invested i.e. costlessly transformed into capital, but the newly produced capital becomes productive only at the beginning of the following period. The capital-labour ratio must be chosen at the moment of transformation of output into capital, from the possibilities determined by an ex-ante production function $Y=F(K,L)$, and the resulting capital good allows only one output-labour ratio, which is

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[8] Investment must anyway be determined over not too short a period, to avoid its being relevantly influenced by transitory phenomena like, for example, a *decrease* of the rate of interest inducing an expectation of a further decrease in a few months' time, and inducing therefore a postponement, i.e. a *decrease*, of investment; or an anticipated scrapping of new plants induced by the change in prices due to a *rise* of the rate of interest, that may induce a temporary *increase* of investment.

[9] The rest of gross investment – partial replacement, without alteration, of capital components of existing plants that are not scrapped, plus purchase of raw materials to be used in already existing plants – will be generally rigidly determined by intended outputs and by the technology embodied in the plants, and will therefore be independent of changes in income distribution except in so far as these affect the composition of demand; accordingly, this part of investment can be taken as given (and for this reason it is permissible to neglect it) as long as normal utilization of existing plants is assumed.

constant as labour employment per unit of capital varies from zero up to a maximum corresponding to the capital-labour ratio originally chosen. (Thus there may be less-than-full capacity utilization of some or all capital goods.) Capital goods last 10 periods with constant efficiency, independently of the *K/L* ratio chosen at the time of their creation and of the level of utilization of the capital good during its life. I abstract from technical progress.

The economy is initially in stationary full-employment equilibrium with capital goods fully utilized: at the end of every period the oldest 1/10 of the capital goods is scrapped and replaced by new capital goods of the same type, produced during the period; the newly installed capital goods utilize in the following period the 1/10 of the labour force which is 'freed' by the scrapping of the oldest capital goods. The real wage equals the marginal product of labour in new plants; once the real wage is fixed, the real rate of interest (I neglect risk) is univocally determined (by – owing to the presence of fixed capital – rather complicated equations into which we need not enter).

Then, let us assume, at the beginning of one period the real wage unexpectedly rises (trade unions or political decisions impose this rise, without a change in labour supply) and it is expected to remain at the new level for many periods, and the real interest rate adapts rapidly, so the optimal *K/L* ratio in new plants rises; the quantity of output destined to investment, let us assume, does not change (this allows us to consider the quantity of capital as not changing); from the subsequent period onwards, part of the 1/10th of the labour supply 'freed' by the scrapping of the oldest plants remains unemployed; the other 9/10ths of the labour force remain employed by the already existing plants, which I assume still yield positive quasi-rents because the wage increase is small. Assume (i) that savings keep translating without difficulty into investment, (ii) that the amount of output destined to gross investment does not decrease in subsequent periods in spite of the decrease in labour employment, so the stock of capital (in the physical sense of total amount of output from which it was created) does not change, (iii) that the real wage does not change. Then after 10 periods the total physical capital K_{Tot} of the economy, measured in physical terms as the sum of the given-up consumption that allowed its creation, has not changed, and labour employment (which is less than labour supply) corresponds to the new lower *L/K* ratio multiplied by the aggregate capital measured as indicated. All employed labour now produces output at the new *Y/L* ratio. The final labour employment as a function of the real wage is indicated by a labour demand curve that traces the marginal productivity of labour when the given physical supply K_{Tot} of capital is introduced into the economy's production function *F(·)*. *This* is the labour demand function that, as Hicks requested, allows the 'form' of the given quantity of capital to become adapted to the real wage.

(A side remark unconnected with the central argument of this paper, but sufficiently important to deserve mention anyway: It would not be unrealistic to interpret the length of the period of this analysis as at least a year – fixed plants often last much longer than 10 years –, so the wage change would take at least 10 years to exert its full effect on employment. The slowness of the adjustment implicit in this theory is seldom fully perceived, so its important consequences escape general recognition. One consequence [10] is that, in order to avoid implausible enormous falls of

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[10] Another consequence – relevant, this one, to the main argument of the paper – is that even the neoclassical economist has little reason to presume that the *negative* effect, to be discussed later, of a decrease of real wages on employment through its negative effect on aggregate demand will be slower and weaker in its

wages whenever unemployment were to arise, the theory must admit the presence of social forces that render wage decreases very slow (Petri 1991: 272-73). But then it is unclear why those same social forces – custom, solidarity, feelings of fairness, aversion to accepting reductions of wage relativities as stressed by Keynes, bargaining power of trade unions, threat of violence, etc. – might not be capable of totally preventing falls of wages even in the presence of unemployment, thus constituting the basis for a determination of wages alternative to the neoclassical tendency toward a supply-and-demand equilibrium, and very much in line with the views of the first attentive observer of capitalism, Adam Smith.)

The assumption that production takes one period (with all productions started at the beginning of a period and ending at the end of the period) means that in each period t the output $Y_t=C_t+I_t$ cannot include the output of plants created by I_t. So Y_t is the result of the full utilization of the plants that the economy has *at the beginning* of the period, each vintage producing and employing labour depending on the amount of capital good of that vintage and on the K/L ratio chosen for that vintage. Thus in order to determine the demand for labour the reasoning takes Y_t in each period as given, determined by the full utilization of beginning-of-period capacity. (Changes of the real wage at the beginning of the period have no effect on labour employment in that period, at least as long as the wage change does not cause anticipated scrapping of plants.)

4. But what if the continuous full employment of labour is not assumed?

To answer the question in the title of this section, let us remember the considerable elasticity of the output of the several industries in real economies, in response to variations in demand (the elasticity that makes the working of the Keynesian multiplier possible). Variations of demand will be met at first by variations of inventories and then by variations of output levels tending to bring inventories to normal – and, in manufacturing industry, generally with little or no change in prices. The premises of this elasticity are not represented in the above model, which lacks inventories, but this elasticity should nonetheless be admitted. And it is well known that firms build fixed plants in the expectation of a level of normal utilization which is considerably less than the technically maximum level (and is nonetheless esteemed to be optimal for the reasons pointed out in the literature on capacity utilization: Marris, Betancourt and Clague, Winston, Heinz D. Kurz etc.), so that not only underutilization of plant, but also above-normal utilization is a possibility. Therefore what in paragraph 5 was called the *maximum* output/capital ratio corresponding to the chosen K/L ratio must more realistically be reinterpreted as the *normal* output/capital ratio, which can be exceeded if demand is above the level in the expectation of which productive capacity was built and no constraint arises from labour availability. And 'full-capacity output' must be interpreted to mean *normal*-utilization output, not an upper limit to actual output.

Once this elasticity of output in response to demand is admitted, then there is no obstacle to admitting an autonomous influence of investment upon output, in either direction. An investment less than normal-capacity savings will encounter no obstacle in causing Y to be less than normal-capacity output even if initially there was full employment of a rigid labour supply. An investment greater than normal-capacity savings will cause Y to be greater than normal-capacity output as long as an

action than the positive effect on the demand for labour coming from capital-labour substitution.

increase in labour employment is possible[11]. Savings will adjust to investment via the variation of *Y* induced by the multiplier.

Once the basic intuition is grasped, it is convenient to abandon the picture of production as consisting of rigidly separate cycles and to admit, more realistically, continuous production and continuous scrapping. The scrapping of old plants causes a flow of 'freed' labour, while new plants absorb a flow of new employment. The moment the possibility of unemployment is admitted, even with a constant employment in the already existing plants the second flow can be smaller than the first, causing a gradual rise of unemployment, or greater than the first, with a gradual reduction of unemployment. The indeterminacy of labour employment in new plants implies that a given *K/L* ratio in new plants leaves investment indeterminate. The conclusion is confirmed that even conceding the neoclassical conception of capital-labour substitution, income distribution is insufficient to determine investment, but then employment too. A given real wage (and corresponding real interest rate and normal relative prices) determines only the ratio *K/L* in new plants, it does not suffice to determine investment (and labour absorption) in new plants. As for employment in already existing plants, the rigid output-labour ratio implies that an assumption of decreasing marginal product of labour cannot be accepted, hence employment in these plants cannot be considered determined by the real wage; more realistically, employment will depend on output which will be determined by sales, and therefore, through the multiplier, by investment. And since the desired *K/L* ratio in new plants leaves investment indeterminate, there seems to be little alternative to considering investment determined by the desire to reach normal capacity utilization, i.e. by the expected level and variations of demand[12].

But before examining some implications of this view of investment, let me note how the above considerations destroy the neoclassical demand curve for labour. What emerges is that no incompatibility exists between a rise of real wages and a constant or increasing labour employment, *even accepting the neoclassical conception of capital-labour substitution*. Capital-labour substitution can operate only in new plants, and a greater *K/L* ratio in new plants implies a lower absorption of labour in new plants and no increase in employment elsewhere only if investment and the other autonomous components of aggregate demand remain constant or decrease; but there is no need why they should, the elasticity of output makes an increase of employment in existing plants perfectly possible if e.g. public expenditure, or investment, increases (in fact, I argue later that neoclassical capital-labour substitution implies that investment *will* increase when the real wage increases). As I have written elsewhere (also cf. Petri 2004, p. 320):

> the flexibility of production in response to changes in demand implies that there is no necessary
> influence, in the short as well as in the long period, of changes in real wages on the demand for labour.
> In existing plants, where capital already has a given 'form', higher real wages will bring about little or

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[11] I.e. as long as normal-capacity output, the one associated with the normal utilization of e\ xisting productive capacity, is less than necessary to employ the entire labour supply, or temporary increases in working hours are possible from the fully employed labour force.

[12] Of course innovation will be another fundamental determinant of investment, but its effects do not seem relevant for a discussion of the validity of Say's Law.

no change in output per unit of labour: employment will depend on capacity utilization which will depend on aggregate demand. In new plants, the flexibility of production of capital goods industries will generally pose no problem with obtaining the inputs required by the adoption of the new most profitable methods of production on the scale suggested by the expected level of aggregate demand, even if the latter is increasing considerably. Thus (apart from political reactions) there generally is no incompatibility between more employment and higher wages, all that is required is that the higher wages be accompanied by a stimulus to aggregate demand. This will be so even when it were the case that a higher wage implied a shift to more value-capital-intensive techniques and therefore required more savings: the increase in savings will be brought about by the increase in aggregate output. (Thus one might say, in neoclassical language, that owing to the adaptability of production to demand, relative factor proportions adapt to income distribution rather than the other way round.) (Petri 2011, p. 411, and footnote 36, p. 416)

Because of the above, empirical enquiries confirming that in most industries wages equal the marginal revenue product of labour would be no confirmation that the marginal product of labour *determines* real wages, because the causality must be understood to go the other way: owing to the adaptability of production to demand it will be prices and methods of production (i.e. the capital goods utilized by firms) that will adapt to a given real wage, so as to render the marginal revenue product of labour equal to the wage.

5. *From Keynes to David Romer.*

What I have argued so far (leaving aside the digressions stressing the potential, in the elements pointed out, for a totally non-neoclassical approach to employment and distribution) is that an acceptance, *coupled with a correct understanding*, of traditional marginalist capital-labour substitution implies that, the moment the continuous full employment of labour is not assumed to start with, the rate of interest does not suffice to determine investment, and a role of accelerator-type influences on investment (and hence on employment) appears inescapable. This must mean that the justifications offered by Keynes and afterwards for a determinate influence of the rate of interest on investment come out, upon attentive study, to be unpersuasive if the full employment of labour is not assumed. I will now defend such a view. Reference when possible to my previous examination of investment theories in Petri (2004, ch. 7) will allow me to be brief. Let me start with Keynes.

Under the influence of Marshall's empiricism on investment Keynes does not seem to feel the need for detailed analysis of why the aggregate schedule of the marginal efficiency of capital is decreasing, treating the thing as something needing little discussion since everybody seems to agree on it; after citing Carver, Taussig, Flux, Marshall, Walras, Fisher he remains content with a reference to a short-period role of the increasing supply price of capital goods (a role that was soon noticed by Dunlop and Tarshis to be empirically unsupported, and was anyway insufficient for a theory arguing the possibility of *durable* unemployment), and to a longer-period role of decreases of the yield of a capital good as its supply is increased, an argument made illegitimate by the possibility to increase the employment of all capital goods together with the employment of labour. Thus Garegnani (1978

fn. 44 p. 59-60) noted, "Keynes's use of the marginal efficiency of capital also presents difficulties. In particular, it is not clear in what sense decreasing returns to increases in the stocks of the different capital goods can be assumed, as is done by Keynes (p. 136), when, there being unemployment, additional equipment be used together with additional labour." [13]

The unclear connection between Keynes's investment schedule, and the marginalist notions appealed to by Keynes in order to support it, is confirmed by the disagreements among later authors on how to give a foundation to that schedule. Many authors even denied that its negative interest elasticity rested on marginalist/neoclassical theory, on the basis, fundamentally, of an "array-of-opportunities" approach: I refer to Petri (2004, pp. 262-269, and fn. 31 p. 276) for a criticism of Marglin, Pasinetti, Minsky, Fazzari, Hubbard, Chick. Among the authors admitting the marginalist or neoclassical foundation, a majority seem not to have seen the problem raised by the abandonment of the assumption of continuous full labour employment; thus Lerner (1944) assumed a given curve of the marginal product of capital shifted in time by net savings, without discussing whether labour employment was full or not (Petri 2004 p. 276); the same blind spot appers afterwards in numerous authors (including Ackley, as noted earlier), down to many recent textbooks that attribute the negative interest elasticity of investment to the decreasing marginal-product-of-capital curve, *without* clarifying what is assumed about labour employment when the latter curve is determined. In my 2004 book I cited as examples the textbook on rational expectations by Begg (1982), and the macroeconomics textbook by Farmer (1999). Here I add the textbook by Burda and Wyplosz (1993), and the one by Mankiw (2003). In the Burda-Wyplosz textbook, like in Farmer's, capital is assumed to be entirely circulating capital (as shown by the fact that its demand is determined by setting its gross marginal product equal to *1+r*), so yearly gross investment *coincides* with the demand for capital, the need for an assumption of given labour employment in order to derive the marginal-product-of-capital curve should be glaring, and yet it is nowhere mentioned; the investment function thus derived is then used in the IS-LM model, where labour employment is *variable*, with no mention of the implications of this fact for the marginal product of capital. Mankiw's textbook too,

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[13] Panico (1988, ch. 4, App. B) shows that Keynes follows Marshall closely on the determinants of investment. By Marshall's 'empiricism' I mean his habit of presenting theoretical conclusions due to complex deductive chains as if they were obvious consequences of empirical observation, the theoretical precise deduction being only vaguely hinted at; thus nowhere does Marshall explicitly detail how an aggregate investment schedule is to be derived; through a variety of concrete examples (*Principles*, V, iv, 3, 4; VI, i, 8, 9) he motivates the negative elasticity of the demand for capital by referring to a decreasing convenience (implicitly suggested as obviously observable in reality) of the investment of extra units of capital in each industry or even firm, and then aggregating the demands "for the loan of capital ... of all individuals in all trades", without making it clear why the extra units of capital run against decreasing returns already at the industry or even at the single firm's level, apart from mentions of the general principle of substitution that leave the precise theoretical reasoning in the dark. This empiricism must have helped Keynes not to realize the illegitimacy of aggregating the decreasing returns to increases of the supply of *single* capital goods (assuming unchanged supplies of other factors) into decreasing returns to a general increase of the stocks of capital goods accompanied by a parallel increase of labour employment.

in the early chapters where the IS-LM model is introduced, treats investment as a function of the rate of interest only, and the justification sounds very much like the 'array-of-opportunities' approach strongly criticized by Ackley [14] ; then in the chapter dedicated to investment near the end of the book he derives the negative interest elasticity of business investment from the decreasing marginal product of capital, which is admitted (p. 464) to be an increasing function of the level of labour employment; but the admission is immediately forgotten, so no mention is made of the fact that an increase of investment in an economy with unemployment, by raising aggregate demand and hence labour employment, will raise the marginal product of capital and therefore there is no guarantee of a decreasing IS schedule. One wonders how the economic profession can have tolerated such inconsistencies.

The problem that loomed central in the discussion of investment theory in the 1950s and 1960s was different: it was the stock-flow issue, famously enunciated by Haavelmo, of how to derive the *speed of adjustment* of the given capital stock to a different desired capital stock if a change in the interest rate causes a discrete change in the desired capital stock. The indeterminacy of the effect of the rate of interest on desired capital due to the indeterminacy of aggregate desired capital when labour employment is not given – a problem *logically prior* to the stock-flow problem – was not noticed. But, by what can hardly have been simply a coincidence, the solutions to the stock-flow problem that acquired greater following, namely Jorgenson's 1967 approach and the currently dominant adjustment-costs approach, did *not* assume a given total labour employment and thus also apparently surmounted the indeterminacy problem (only *apparently*, because of their unacceptable assumptions). I must admit to an insufficient clarity on this issue in my 2004 book, where I did point out the scandal, in these two approaches, of the passage from the analysis of a single firm to aggregate investment by assuming "that the macro function is simply a 'blown-up' version of the micro function" (Junankar, 1972, p. 61), a passage that must exclude free entry [15] and must also forget that the assumption of given input and output prices made when analysing a single firm, and legitimate if only that firm changes its choices owing to a change of the rate of interest charged *to it and to it alone*, is clearly illegitimate when the change of the interest rate is general and alters the behaviour of all firms; but I did not adequately stress the fortunate coincidence by which solutions to the stock-flow problem also allowed forgetting about the indeterminacy problem [16] .

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[14] Cf. "If the interest rate rises, fewer investment projects are profitable" (Mankiw, 2003, p. 55) and the immediately following example where the return to an investment project is treated as unaffected by changes of the interest rate.

[15] Otherwise aggregate investment becomes indeterminate even when a well-determined investment decision can be obtained for existing firms – this last one actually another thorny issue, that Jorgenson (1967) can only solve by assuming, without any attempt at a justification, decreasing returns to scale for individual firms. The weaknesses of Jorgenson's (1967) approach are pointed out in greater detail in Petri (2004, pp. 287-90) and appear responsible for the current lack of favour of the approach, which leaves the adjustment-costs approach as the dominant one.

[16] The absence of a full employment assumption is revealed by the treatment of firms as free to determine the amount of labour they employ: this is what is assumed both in Jorgenson and in the adjustment-

The recent developments in neoclassical macroeconomics that assume continuous equality between labour demand and labour supply eliminate the problem by doing away with an investment schedule or function; investment is simply *assumed* equal to savings. These developments will be discussed in the last Section. The recourse to adjustment costs remains the dominant and unacceptable way to arrive at a decreasing investment function when the need for an investment function is admitted, and it constitutes a terrible miseducation of students, who are induced to accept assumptions that contradict basic microeconomic theory, and to lose all perception of the traditional role of capital-labour substitution in neoclassical theory. To prove it, I examine the widely used advanced macroeconomics textbook by David Romer, in its second edition (2001) which in the chapter on investment has not undergone fundamental changes in subsequent editions [17] .

I will discuss only the main characteristics of Romer's basic determination of investment in Sections 8.2 to 8.5 of chapter 8 (for space reasons I refer the reader to the book for the full analytics). This basic model uses adjustment costs to determine the time path of the capital stock of a firm which is one of N *identical* firms forming an industry facing a downward-sloping demand curve (notice the *given* N, i.e. no entry). The firm is price-taker, but while input prices are given, the output price depends on total industry supply, which depends on the amount of capital of the (identical) firms in the industry. "Each firm takes the path of the industry-wide capital stock, *K*, as given" and in fact correctly forecasted, Romer assumes (p. 370), which together with a correct knowledge of the demand function allows each firm to have correct foresight of the time path of the output price (this assumption of correct foresight is obviously disputable [18] , but this is not my main concern now). Capital is treated as if it were a single homogeneous good measurable in physical units (as usual in neoclassical macro literature, there is no hint that capital is physically heterogeneous and that therefore the 'amount' of capital can only measure the *value* of capital goods, which will change with changes in the interest rate). The firm's profits [19] at time *t* "neglecting any costs of acquiring and installing capital" take the form $\pi(K(t)) \cdot k(t)$, where the function π is a value function indicating the maximum 'net revenue' (gross of interest payments) of the firm *per unit of capital*, that is, the cash flow left to the firm (per unit of capital) out of sales revenue when other factor employments are optimal for the given capital *k(t)* of the firm and all factor costs are paid *except* the rate of interest on the capital employed (cf. how π is defined at the beginning of the chapter, p. 367, where however it is

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costs approach for the single firm, and hence also implicitly for the aggregate labour employment decision of the given number of firms.

[17] I have been stimulated to analyze Romer's treatment of investment by the Siena University Master dissertation in Economics by Riccardo Pariboni.

[18] This assumption of perfect foresight is required in order to avoid explosive paths of the industry's capital stock (because the optimal path is a saddlepath), but Romer supplies no discussion of the plausibility of such an assumption.

[19] In this paper 'profits' stands for the neoclassical and not the classical meaning of this term, but here the qualification "neglecting any costs of acquiring and installing capital" implies that Romer intends profits gross of interest payments, so in this specific case 'profits' comes to have the classical meaning.

not per unit of capital); thus the technology has constant returns to scale if one neglects adjustment costs. Romer imprecisely calls π "marginal revenue product of capital" (p. 373), but the usual definition of the marginal revenue product of a factor takes the other factor employments as given, while here π indicates the increase in 'net revenue' when one more unit of capital is used *and* the employment of other factors is optimally adjusted. Actually π is a function not only of K, the industry-wide capital stock, but also of all the variables that the firm takes as given, which are the rentals of the non-capital inputs; but these are treated as given and unchanging, so K is the only variable whose variation over time is relevant to determine the time path of the industry's output price. Romer admits in a footnote that with constant returns to scale, in the absence of adjustment costs "the firm's demand for capital is not well defined" being either infinite or zero or indeterminate (p. 371 fn. 3). (Note that this implies that the firm is not constrained in the amount of non-capital factors it employs.) But at this point Romer has already argued for the introduction of adjustment costs, on the basis of the observation in the first Section of the chapter (p. 369) that, if one assumes a well-determined optimal size of the firm's capital stock, since any discrete change in some exogenous variable would cause the demand for capital to change discretely, an immediate adaptation of the capital stock would require an infinite rate of investment, so one needs something causing the desired speed of change of the capital stock to be finite. This is the stock-flow problem mentioned above. Having thus justified earlier the introduction of adjustment costs, Romer can now admit constant returns to scale because owing to them even if the firm's optimal capital stock (neglecting adjustment costs) becomes infinite, the optimal speed of expansion of the capital stock will be finite anyway.

Romer's assumptions on adjustment costs are standard; his main novelty relative to earlier literature on adjustment costs is that earlier literature considered, like Romer, a single firm, but stopped at the assumption that the firm expects a given output price (over the infinite future!), while he considers the demand curve facing the industry to which the firm belongs; this is a step forward, it allows Romer to admit an influence of aggregate demand on the position of that demand curve and thus on the industry's investment decision. Romer must be congratulated for admitting that "there is ... almost overwhelming evidence that income influences investment" (p. 220), and for noting that the main influence is that of *changes* of output, and using the term 'accelerator' to define it (p. 383) [20] . Even if, as my criticisms below imply, the specific way in which he formalizes the influence of shifts of the industry's demand curve on investment should be found unacceptable, still his admission of the empirical evidence of an accelerator influence upon investment is important, and other ways to study how this influence operates are not missing (e.g. Ackley's chapter 19). But this accelerator influence is not what is needed for Say's Law; on the contrary it weakens it, because it opens the door to the possible instabilities of multplier-accelerator interactions, and to the evolution of autonomous demand as the main long-run determinant of investment and growth, as e.g. in the radically non-neoclassical view of the determinants of distribution employment and growth of the 'Sraffian'

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[20] The same admission of an influence of output on investment is in Heijdra and van der Ploeg (2002), but it is arrived at in a very unsatisfactory way, cf. Appendix 1.

school[21]. What makes it possible to base growth theory on full-employment models is the thesis that investment adjusts to savings, an adjustment that must rely on the rate of interest. Let us then turn to how Romer explains the negative influence of the rate of interest on investment.

This requires presenting in greater detail how Romer determines the single firm's decision. Expenditure caused by investment *I* (which is *net* investment and hence coincides with the rate of change of the firm's capital stock, because for simplicity capital is assumed eternal) is the sum of the purchase price of the capital added to the existing capital stock (its unit price is assumed equal to 1) and of the additional adjustment costs *C(I(t))*, an increasing and convex function. Romer writes that "the firm's profits at a point in time are *π(K)k–I–C(I)*. The firm maximizes the present value of these profits", that is, in the discrete-time version which is more intuitive, the firm maximizes

$$\Pi = \sum_{t=0}^{\infty} \frac{1}{(1+r)^t} \left[\pi(K_t)k_t - I_t - C(I_t) \right] \quad subject\ to\ k_{t+1} = k_t + I_t. \qquad (8.7)$$

This is expression (8.7) p. 372 of Romer (2001). (In Appendix 2 at the end of the paper I show that Romer's description of *π(K)k–I–C(I)* as 'profits at a point in time' is unacceptable, and possibly the reason why expression (8.7), as well as the equivalent (8.6) that applies to continuous time, are mistaken in the determination of profits, a mistake so far unperceived and common to all the literature of this type; but the mistake does not fundamentally vitiate the analysis, so here I concentrate on other weaknesses.)

The negative interest elasticity of investment is obtained by Romer in a way that can be described in intuitive terms as follows. For brevity I consider only the situation where investment is positive. From the above maximization problem Romer derives (p. 372) that the firm invests to the point where the unit cost of acquiring capital, that is the purchase price of capital plus the marginal adjustment cost C'(I_t), equals the value to the firm of one more unit of capital after that unit of capital is installed (i.e. at time t+1, in the discrete-time formulation), a value indicated by Romer as q_t; this is the discounted value of the increase in 'net revenue' π that the installation of the extra unit of capital at t makes it possible to obtain from t+1 onwards. If the output price were expected to remain constant, since input prices are assumed given and constant, and since the increase in output from one more unit of capital is constant (because the firm increases capital *and* the other factors), the extra 'net revenue' caused by an extra unit of capital would be constant, and q_t would be the greater the smaller the discount rate i.e. the smaller the rate of interest, hence investment (and marginal adjustment cost) would be a decreasing function of the interest rate in the current and in the subsequent periods. In fact if, for a given rate of interest, initially a positive investment is convenient the output price will decrease over time (if the demand curve doesn't shift outwards) because the industry's supply increases over time; therefore the path facing the perfect-foresight firm is one of decreasing 'net revenue' per unit of capital, tending asymptotically to one which is just sufficient to repay interest on the given capital stock, with a consequent tendency of investment too to slow down

[21] E.g. Garegnani and Palumbo (1998). But Romer does not discuss these potential implications of his own admission of an important influence of sales on investment. Evidently students must be kept ignorant of the existence of an ample non-neoclassical literature on growth.

tending asymptotically to zero (the presence of adjustment costs renders investment zero when the rate of return apart from adjustment costs is equal to the rate of interest). Thus the effect of a smaller rate of interest is again to increase investment, shfting upwards the entire investment path as well as the K to which the industry's capital stock asymptotically tends. The intuition applies unaltered to the analysis in continuous time (p. 374).

Three aspects of this analysis will be subjected here to critical comment. (I leave aside the well-founded objections to the assumed strictly convex shape of the adjustment costs function, in order to concentrate on theoretical mistakes less often noticed.)

The first one is, that the determinateness thus obtained of the industry's investment path is illusory, because the analysis *has omitted entry*. There is no justification in Romer – nor in the other literature based on adjustment costs – for excluding entry; nor would justifications to such an effect be acceptable, since entry is a phenomenon obviously occurring in real economies. The trouble with entry is that when output price is greater than average cost the potentially infinite investment, eliminated at the level of the single firm through adjustment costs, reappears as due to a potentially infinite number of new entrants. To put it differently: until investment due to entry is determined, total investment remains indeterminate even if one is able to determine the investment of already existing firms.

This indeterminateness is not inevitable, it is due to the structure of the approach, that determines the investment *of the single firm*, and therefore needs a *given* number of firms to determine total investment and yields indeterminate results if the number of firms is variable. This approach has won the economists' favour because it seemed the only way to surmount the stock-flow problem, but this problem is in fact largely non-existent. Changes *in normal sales* are most of the time gradual, and therefore the stock-flow problem, which arises when there is a *discrete* (and significant) change in desired productive capacity, does not arise in this case: a capacity that adapts to a *gradually* changing normal output does not imply an infinite investment. It is the discrete changes in technology, i.e. (for a neoclassical) *in optimal factor proportions*, due to discrete changes in the rate of interest that were thought to originate, in the neoclassical approach, the stock-flow problem; but the more correct view illustrated in Sections 2 and 3, of existing durable capital as unable to change 'form' but continuing to produce and earning quasi-rents until scrapped, implies that the new technology applies to new plants only and therefore does not cause an infinite investment, but only a discrete change in the finite flow of gross investment in new plants required to maintain productive capacity equal to the gradually changing expected normal sales, i.e. to make up for the loss of productive capacity due to the gradual closing down of the oldest plants and to add a flow of increase of productive capacity if an increasing aggregate demand so requires. Thus admitting entry does not cause any indeterminateness of investment; and such a derivation of investment is compatible with non-neoclassical approaches to distribution and aggregate demand.

The second aspect deserving criticism is the independence of the 'net revenues' from the rate of interest. The mistake here would be perfectly evident if the output price had been taken by Romer as given, like in earlier analyses based on adjustment costs: a determination of investment based on

prices and hence on rates of return independent of the rate of interest is unacceptable as already noted: competition (enforced by entry if necessary) will be quick in causing prices to tend toward normal long-period values and rates of return on supply price to tend to *equal* to the rate of interest (neglecting risk for simplicity), for example if a good produced by one unit of labour requires ripening for a year after the wage *w* has been paid, the normal price of the good will be *w(1+r)* where *r* is the rate of interest, and owing to competition a decrease of *r* will cause a decrease of the good's price relative to the money wage that re-establishes equality between rate of interest and rate of return, and therefore will *not* stimulate investment, if investment is to be caused by a divergence between price and average cost. It seems to escape many modern theorists that this was fully accepted by traditional neoclassical theory, which argued that a lower rate of interest would stimulate investment by treating prices as adjusted to normal costs both before and after the decrease of the rate of interest [22] , and relied on the induced change in technology and in the composition of consumption demand in favour of a higher average capital-labour ratio at the new zero-profit prices. Only such an approach could yield the persistent effects needed by the theory: if the rise of investment had been attributed to the temporary divergence between average cost and price, the subsequent re-establishment of prices equal to normal costs would have annulled the temporary increase of investment and undermined Say's Law.

The mistake is made less evident in Romer by his partial-equilibrium analysis where the industry faces a decreasing demand curve, so a lower rate of interest eventually causes a tendency of the product price to a lower price through an increase of output. But Romer too in fact tries to determine the investment function by changing the rate of interest but not the rates of return: the mistake is there, and it emerges in the treatment of the prices of inputs as independent of the rate of interest. To see it, let us assume that the industry in question produces a consumption good, say bread, with labour and corn as inputs, while corn is produced by corn and labour; then if the rate of interest decreases, the price of corn will tend to decrease relative to the money wage as argued above, so the real wage in corn rises; in the bread industry we can keep the price of corn fixed and equal to 1 by choosing corn as numéraire [23] , but then we cannot keep the wage unchanged when the rate of interest changes. So the assumption of given input costs when the rate of interest changes is unacceptable. Of course a given position of the demand curve is also unacceptable in general, since incomes of consumers and prices of other goods change; but in order to grasp the relevance of shifts of the demand curve let us at first assume that the change in income distribution caused by the decrease of the rate of interest does not affect the *composition* of demand, because all consumers are both workers and capital owners in equal proportions so their income is not affected, and because all goods have the same 'organic composition' and therefore relative normal prices are independent of income distribution. With these assumptions the position of the demand curve for bread is not altered by the change of the rate of interest. But the higher wage causes the 'net revenue' to have decreased

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[22] On the need for such an assumption for the study of investment cf. Garegnani (1983, p. 36 and fn. 25 p. 46), also Petri (2011b p. 67).

[23] The numéraire must not be bread if we want to be able to draw a demand curve for bread.

for each output and associated price of bread, so if before the change in distribution the price of bread was the normal long-period one, just sufficient to cover costs and to repay the rate of interest leaving no profit, after the decrease of the rate of interest the same output will cause the same price of bread which will again leave zero profits: there is no incentive to net investment, just like before the decrease of the rate of interest. Of course in real economies there would be changes in the composition of demand, but unless these caused the changes in economy-wide relative factor demand (be it because of changes in production methods or of changes in the composition of consumption) on which traditional neoclassical theory relied, one would only have a tendency to disinvestment in the industry where demand has decreased, compensated by a tendency to investment where demand has increased, with no tendency to nonzero net investment. This shows that the adjustment-costs approach, which leaves no room for capital-labour substitution since it treats input prices as given and labour employment as changing in step with capital, should be classified with the attempts to derive a decreasing investment schedule *without* relying on capital-labour substitution – and that Ackley was perfectly right in denying the possibility of such a derivation.

A third aspect deserving notice is that the treatment of all firms in the given industry as free to change the amount of labour they employ when they change their capital stock requires, in order for a generalization of the analysis to the entire economy to be possible (leaving aside here for the sake of brevity other reasons for the illegitimacy of such a generalization, such as the independence of the position of the demand curve of the industry from the investment decision [24]), that there be free availability of extra labour: the analysis then is incompatible with the situations of full employment of labour, assumed in most of the remainder of the book, which remain therefore without a theory of investment capable of justifying them.

Therefore there seems to be no alternative for the neoclassical economist to reliance on capital-labour substitution, but then the problem reappears of the indeterminacy of investment unless the full employment of labour is *assumed*.

6. *Instabilities*.

But—the neoclassical economist will object—all the above is based on *not* assuming the full employment of labour, and this can be at most a transitory state if the labour market is competitive: the decrease of real wages will increase the demand for labour. But will it really? I have argued that the neoclassical decreasing demand curve for labour is destroyed by the analysis developed so far. So the effect on employment of a tendency of real wages to decrease in the presence of non-frictional unemployment must be examined anew[25]; and a readiness of workers to accept wage decreases as the

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[24] The analysis aims to indicate the effect of a decrease of the rate of interest on *aggregate* investment, but the increase of the latter raises aggregate demand, and therefore shifts the position of the demand curve of the industry. From whatever angle one considers it, the analysis reveals such inconsistencies that its widespread acceptance is a shame on the economic profession.

[25] Keynes objected that, unless investment increases and absorbs the increased saving associated with

normal answer to the existence of unemployment will not be credible if—as I will argue—such decreases do not generally bring about an increase in employment even accepting neoclassical capital-labour substitution.

In existing plants, I have argued that labour employment depends on sales, not on the real wage; an increase of employment requires an increase of sales i.e., leaving government intervention and changes in the propensity to consume aside, an increase of investment. In new plants, conceding the neoclassical conception of capital, the decrease of real wages reduces the K/L ratio. Let us assume that investment is motivated by desired productive capacity and that the economy has been stationary for some time so initially entrepreneurs have little reason to expect anything but the same demand also for the next few years. Let us further initially assume that existing plants keep being normally utilized. Then the new plants can only aim at satisfying the same demand that was satisfied by the scrapped plants they are replacing. Let us initially consider only the direct substitution mechanism. The decrease of the K/L ratio in new plants planned for a given output corresponds to a shift on a given isoquant toward using more labour and less capital, hence *it reduces investment*. If aggregate demand did not decrease, this would not prevent an increase in the demand for labour in new plants (although a smaller increase than if *I* remained constant, see below) and a constant employment of labour in existing plants, and hence some increase in the total demand for labour; but *the decrease of investment reduces aggregate demand, and by more than its decrease owing to the multiplier*; then the assumption that the already existing plants keep being normally utilized comes out to be illegitimate, because the reduction of sales has a negative effect on employment in existing plants; thus even though the *flow* of employment in new plants increases, the overall level of employment *decreases*[26]. Furthermore sooner or later the planned investment in new plants will be revised downwards as expectations of unchanged sales come out to be too optimistic; this further reduction of investment may well be small or even absent initially, but since *Y* remains lower than initially (its rise would need a rise of investment, while there is no incentive to such a rise) this will gradually persuade firms that they do indeed need a smaller productive capacity. Thus the decrease in wages starts a reduction of investment *and employment* that can go on for a long time[27].

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the increased output brought about by the greater employment, the decrease in real wages and increase of employment will not happen, because workers can only reduce *money* wages, and the insufficient aggregate demand will cause prices to decrease in step with money wages. This argument rests on an assumed decreasing marginal product of labour in the several plants, so if real wages were capable of permanently decreasing, the demand for labour *would* rise; I wish to question the robustness of the neoclassical argument *even conceding* a decrease of real wages. Below (§9) I discuss money wages.

[26] Consider the following numerical example. Suppose I/Y is constant, the average life of plants is 10 years, and the reduced K/L ratio causes L/Y in new plants to rise by, say, 5%; the first year the increased hiring of labour in new plants as a percentage of previous labour employment is 5% of 10% i.e. one half of one percentage point. If investment decreases by, say, 4%, this causes a reduction of Y (and plausibly of employment in existing plants) by 4%, i.e. about a 3.5% reduction of labour employment.

[27] This conclusion is reached without considering the negative effect on Y due to the generally admitted rise in the average propensity to save caused by the decrease of the share of wages in national income, an effect which, if admitted, strengthens the argument.

Now let us consider the indirect factor substitution mechanism. It is well known that this mechanism may not work in the direction needed by neoclassical theory, but neglecting for the sake of argument the possibility of 'perverse' income effects, the decrease of real wages changes the composition of consumption demand in favour of labour-intensive goods. The traditional derivation, from this change, of an increased demand for labour rests on an assumed unchanged total employment of capital, which in our framework where capital is putty-clay must mean an unchanged total investment. Like for the direct substitution mechanism, this assumption has no justification in view of the freedom with which investment can be decided. Like in the other case, there is no reason for firms to expect future aggregate demand to be the greater one connected with *more* labour employment and an *unchanged* capital stock, since current aggregate demand is forthcoming from the income of the given capital and the not yet increased labour employment, only its composition is changing. The more plausible assumption is that the total value of expected demand for consumption goods is equal to the total current expenditure on them, and its changed composition corresponds therefore to a greater demand for labour and less demand for capital, that is, like in the direct-substitution case, less investment. Then the effect is the same as in the other case, a reduction of aggregate demand that causes a reduction of labour employment, with a likely subsequent further discouragement of investment.

7. Dornbusch and Fischer.

I am not the first to argue that even neoclassical theorists should admit an influence of expected sales on aggregate investment (in other words, a role for the accelerator broadly intended). This influence was admitted in the first (1963) version of Jorgenson's 'neoclassical' approach to investment [28] , and in the popular macroeconomics textbook by Dornbusch and Fischer.

The basic idea of the approach of these economists was precisely, in accord with what I have argued, to take output, i.e. (expected) aggregate demand, as given instead of labour employment in order to determine the desired capital stock and hence investment. Output is treated as if homogeneous and homogeneous with capital; then only the direct substitution mechanism can be explicitly formalized. The rate of interest selects the average capital-labour proportion on the aggregate isoquant corresponding to the planned level and composition of aggregate output; the desired capital stock changes if either the rate of interest, or planned output (i.e. expected demand), or both, change. Thus the desired capital stock is determined by the neoclassically determined capital/output average ratio, *and by the level of aggregate output*. A lower interest rate raises the desired *K/Y* ratio; with expected *Y* initially unchanged, the desired capital stock increases, although by less than if *L*, rather than *Y*, were kept fixed; the increase of the desired capital stock causes an increase of investment. Thus in the 3rd edition (1984) of their macro textbook Dornbusch and Fischer explicitly consider the desired capital stock *K** to depend both on the rate of interest and on the level of output, writing their equation (2), p. 206, as

$K* = g(rc,Y)$

where *rc* is the rental (user) cost of capital, identified (if one neglects depreciation and taxes) with

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[28] On the considerable difference between Jorgenson's 1963 approach and the 1967 one, a difference often neglected, cf. Petri (2004, pp. 287-290).

the rate of interest. The function is specified two pages later, where (footnotes 4 and 5, p. 208) they assume a Cobb-Douglas aggregate production function $Y=N^{1-\gamma}K^{\gamma}$ and then write:

$$K* = \left[\frac{\gamma w}{(1-\gamma)rc} \right]^{1-\gamma} Y \ . \qquad\qquad\qquad \text{(equation 3a)}$$

If in this equation one replaces w with the marginal product of capital, and rc with the marginal product of labour, one obtains an identity; that is, w equals the marginal product of labour and rc equals the marginal product of capital, i.e. $K*$ is determined by Y and by the tangency between isoquant and isocost, and (neglecting depreciation) factor payments exhaust the product; the given Y implies, and footnote 5 states it explicitly, that labour employment is not kept fixed when the rate of interest varies, it "is being adjusted so that *output* is kept fixed". This implies that the real wage too does not stay fixed when the rate of interest is varied, it adapts so as to bring profits to zero.

The presence of the influence of Y on desired capital explains Dornbusch and Fischer's use of the term 'flexible accelerator' as an alternative denomination for this approach, which following Jorgenson they also call the 'neoclassical approach' to investment. The approach needs of course the traditional and unacceptable marginalist conception of capital-labour substitution, and furthermore it is left with the problem of the speed with which the desired capital stock is reached when it changes discontinuously owing to a jump of the rate of interest[29]; but at least it avoids the frequent grave mistake, pointed out in §5, of a derivation of the negative interest elasticity of the investment function from a *given* downward-sloping marginal-product-of-capital curve, as if labour employment could be assumed given [30] . However, the avoidance of that mistake pays a price: the consequences I have started to point out in §6, and will now explore further.

Dornbusch and Fischer are not induced by their admission of a significant influence of output and its variation on investment to raise doubts on the IS-LM model and on the AD-AS model; therefore one can interpret them as believing that, since (if expected Y is given) the negative interest

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[29] This speed is determined by Dornbusch and Fischer through a 'gradual adjustment hypothesis' that states that the larger the gap between the existing capital stock and the desired capital stock, the more rapid is the adjustment i.e. the greater is investment. Empirical evidence is then referred to in order to estimate the speed of adjustment. Like in Jorgenson (1963), there is little theoretical justification for this hypothesis apart from some hints on the importance of construction lags, time-to-build. I do not think that on this issue one can go much farther anyway. As argued in §5, the greater determinateness of investment achieved by the adjustment-costs approach is totally illusory; certainly it is possible sometimes to accelerate the speed of construction of new plants by special efforts, and certainly sometimes some firms will find it convenient to incur such extra costs in order to exploit particularly convenient opportunities before other competitors do (this is the kernel of reasonableness behind the adjustment-costs approach, cf. Petri, 2004, p. 277, fn. 32); but such decisions depend on specific transitory circumstances, and their disequilibrium character always involves some accidental element, therefore it seems necessary to be content with the tendency of the average.

[30] However, Dornbusch and Fischer also justify the investment schedule through the 'array of opportunities' approach which, they argue, is compatible with the desired-capital approach (pp. 219-220), without realizing that the second approach assumes an adaptation of the rate of return on capital (and of real wages) to the rate of interest, while the first approach assumes rates of return independent of the rate of interest as the two authors make clear on p. 103.

elasticity of desired capital and hence of investment obtains in their approach too, the 'neoclassical synthesis' criticism of Keynes is valid: a downward flexibility of money wages would ensure a tendency toward full employment, owing to the 'Keynes effect' remembered in §1.

But their different approach to investment opens the road to a number of objections even without questioning the neoclassical conception of capital-labour substitution.
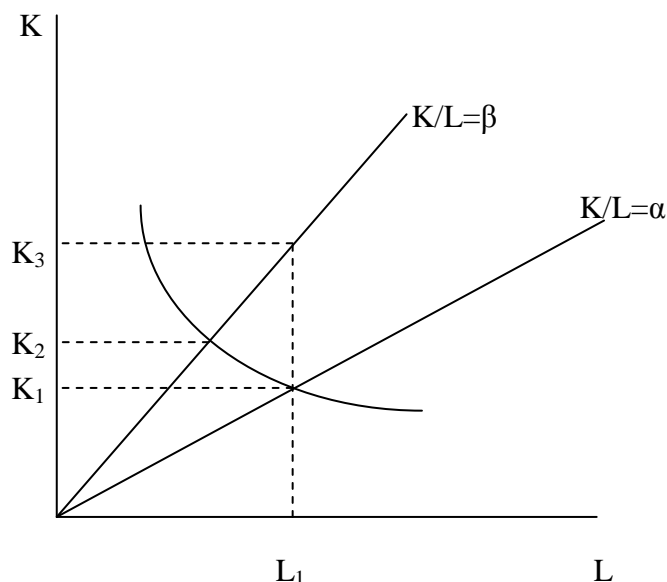
(Intl. 17pt)

Fig. 1

First objection. The presence of an accelerator influence upon investment makes consideration of what has been happening to Y important. If, starting from a situation of desired capital-output ratio equal to the actual one, Y decreases for any reason (e.g. because of a decrease of exports, or of state expenditure) and remains low, then desired K is lower than actual K, and investment is discouraged; and this, through the multiplier, causes Y to decrease further, stimulating further decreases of desired K. The decrease of the rate of interest brought about by the 'Keynes effect' must then supply a *very* strong stimulus to investment to reverse this downward process. Such a strong stimulus cannot be expected, for two reasons. The first one is that the increase of desired K is smaller than the one derived from the standard demand-for-capital curve, because the latter determines desired capital on the basis of a given employment of labour, while here firms move along a given (K,L) isoquant: this is shown in Fig. 1, where the isoquant corresponding to a given Y is shown, and a change in distribution that changes the optimal K/L ratio from α to β causes an increase of desired capital from K_1 to K_3 if labour employment is fixed at L_1, but only from K_1 to K_2 if output is fixed. The second reason is that the increase in the K/L ratio can be realized only in new plants, so it concerns only a very limited portion of productive capacity in every year. (The slowness of the change in the K/L ratio pointed out in §5 should not be forgotten: it is generally underestimated, owing to a mistaken tendency to conceive capital as putty-putty. Therefore the influence of Y on desired productive capacity and hence on investment has sufficient time to manifest itself.) Therefore even a neoclassical economist has little reason to expect the 'Keynes effect' to be more powerful than destabilizing multiplier-accelerator interactions.

Second objection. As equation (3a) makes clear, Dornbusch and Fischer implicitly recognize – in accordance with standard microeconomics – that the marginal products of the two factors labour and capital are tied together in such a way that if one marginal product increases, the other one decreases, and that factor prices adjust to marginal products so that normal competitive extraprofits net of risk must be assumed to be zero when one studies investment [31] . This means that an increase of the desired K/L ratio will be associated with a change of relative factor prices consisting of a decrease of the real interest rate and an *increase* of the real wage. In order for the marginalist factor substitution mechanisms to stimulate investment by raising the average K/L ratio in new plants, the real rate of interest must decrease i.e. *the real wage must increase*. On the contrary, the first stage of the 'Keynes effect' mechanism supposed to raise employment if money wages decrease consists of a *decrease* of real wages: firms raise employment and production because money wages decrease relative to prices that have not decreased yet; once prices start decreasing, since plausibly they decrease with some lag relative to the decrease of money wages, the real wage perhaps stops decreasing but remains lower than initially for all the deflationary period. As pointed out in §6, then investors have an incentive to adopt a *lower K/L* ratio in new plants, and this causes a *decrease* of investment. To avoid this result, it would seem necessary that the decrease of real wages be strictly temporary, soon reversed by an *even greater* decrease of the price level (caused by prices rapidly adjusting to average costs including not only lower money wages but now also a lower rate of interest); then because of the rise of real wages the desired K/L ratio in new plants increases; this will hopefully stimulate investment, and Y, to the point of raising the demand for labour *in spite of* the rise of real wages. But note how one will be then admitting the possibility and indeed *necessity* of raising at the same time employment and real wages! Then it becomes difficult to deny that it must be the task of public intervention to secure such a result without the slowness and uncertainties of leaving it to the spontaneous working of the market, which would anyway not guarantee at all to work in the needed direction, because there is little reason to expect the necessary greater decrease in the price level to be sufficiently fast – firms are notoriously hesitant to decrease prices –, and furthermore it is well known that price decreases raise the weight of debts with possible negative effects on production and investment. (To all this one can add the well-known negative effect on the propensity to consume, and hence on the multiplier, associated with a decrease of real wages.) It is anyway striking that the rise of employment will have to be associated with a rise, not a decrease, of real wages. (Is this perhaps the reason why the Dornbusch-Fischer approach was not more widely adopted and was subsequently totally forgotten?)

8. Summing up thus far; and two implications for an alternative theory.

These considerations should suffice to show how little one can trust – even accepting the neoclassical conception of capital-labour substitution – that a downward flexibility of money wages will reduce unemployment, the moment one more consistently develops, when the full employment of labour is not assumed to start with, the implications 1) of the fixity of the 'form' of durable capital, 2) of remembering that in the neoclassical approach the rate of interest determines only the *ratio*

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[31] Obviously because capital is putty-clay the extraprofits to be considered are the ones on new plants, existing plants earn quasi-rents.

K/L, 3) of the inevitable influence of expected demand on investment, and 4) of the multiplier, and of possible multiplier-accelerator interactions broadly conceived. The blindness to these implications is striking, in view of the fact that point 1 had been stressed by Hicks, Robertson, Stigler; points 2 and 3 were accepted by no less economists than Dornbusch and Fischer; and the multiplier was known to everybody and there was a considerable literature on multiplier-accelerator models. One is induced to suspect, behind this blindness, the same influences that it seems necessary to hypothesize to explain the scandal of the widespread acceptance of the adjustment-costs approach: in macroeconomics the pressures seem to be enormous not to abandon an optimistic view of the self-adjusting capacity of markets.

Little wonder then if the empirical evidence that consistently suggests the overwhelming importance of accelerator-type influences on investment is not made the basis of macroeconomics, and students continue to be taught that investment adjusts to savings when reality so clearly shows the opposite. Little wonder also, if the Cambridge debates in capital theory are never mentioned and capital continues to be treated like a single factor nicely substitutable for labour. None so deaf as those who will not hear. It is to be hoped that younger minds will find the courage of independent thinking, which inevitably will bring them, because of the empirical evidence, because of the capital-theoretic criticisms, and because of the arguments of this paper, to conclude that there is no reason at all to believe in Say's Law and in a spontaneous tendency of market economies toward the full employment of labour.

Two important implications of this conclusion may be pointed out to these younger minds.

The first one is that the assumption that in the presence of unemployment money wages will decrease becomes implausible, and the thesis, that if in the presence of unemployment wages do not decrease then unemployment must be voluntary, loses its analytical foundations. If reductions of wages have little or no effect on labour demand and can even have a negative effect, cumulative historical experience will have taught this fact to the labouring classes, ways will have been found to teach this knowledge and the consequent appropriate rules of conduct to the young, and it is then perfectly understandable that an unemployed worker will not, apart from exceptional circumstances, try to obtain a job by undercutting others. The generalized reduction in wages that wage undercutting would bring about would not reduce unemployment, it would only worsen the incomes of employed workers – who often are the relatives of unemployed workers, from whose income the living of the latter may depend. In such a situation it would be mistaken to define *unemployment* as voluntary: the absence of wage reductions is voluntary, but not unemployment. The unemployed worker by refusing to accept a lower wage is *not* choosing the alternative "no wage reduction, no job" over the alternative "wage reduction, job" [32] .

The second implication is the need to reconsider the theory of growth. The elasticity of output with respect to demand pointed out in Section 4 strongly suggests a view of economic growth and capital accumulation as dependent on the evolution of aggregate demand, because it implies that *aggregate* production can quickly adjust not only to decreases of aggregate demand, but also – within limits rarely approached – to *increases* in aggregate demand, so that it is generally possible,

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[32] And if the worker refuses available jobs offered at a lower wage, the reason is again that lower wages must not be accepted because it would mean giving in, in the perennial conflict on income distribution.

even in economies very close to full employment, to raise at the same time consumption *and* investment, if aggregate demand increases[33]. A fast expanding literature is developing these insights [34].

9. Implications for DSGE models.

It remains to point out the relevance of the above analysis for the approaches to macroeconomics where, like in Dynamic Stochastic General Equilibrium models, the problems for Say's Law pointed out in this paper are pushed out of sight by an *assumption* of continuous full employment of the labour supply, and therefore of savings determining investment. This is taken so much for granted that some New Keynesian authors, e.g. Galì ??, have found it possible to present their approach in models without capital (and therefore without investment), evidently convinced that the introduction of investment would present no new problems. This assumption of savings determining investment is not supported by a proof of stability of the equilibrium [35] ; it is justified by reference to the need that macroeconomics conforms to the 'rigorous' microfoundations supplied by general equilibrium theory: the models are argued to be simplified renditions of the results one would derive from completely disaggregated intertemporal general equilibrium models, possibly made more realistic by the admission of adjustment costs, imperfect competition, and so on. The claimed premise of these models is therefore that intertemporal general equilibrium theory is a robust descriptive theory [36] .

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[33] Labour constraints are usually not binding in the short run because of visible or hidden unemployment and underemployment, and over the longer run there are migrations, and structural social adaptations e.g. changes in the participation of women.

[34] Cf. e.g. Garegnani and Palumbo, 1998; since then this literature, that includes Petri (2003), has greatly expanded.

[35] Adjustment costs are usually introduced in the specification of investment but, as shown e.g. by Wickens (2008) who mentions them but judges them an unnecessary complication and does not introduce them in the model, they are not deemed indispensable; evidently the adjustment of investment to savings is considered indubitable.

[36] Relative to the period of debates between Keynesians and monetarists, the novelty is the turn to a version of the pre-Keynesian marginalist approach which is even more extreme than the historical pre-Keynesian versions, because Say's Law and equilibrium on the labour market are assumed to hold *continuously* along a perfect foresight (stochastic) path. Pre-Keynesian marginalist economics admitted disequilibrium unemployment during recessions, modern mainstream macroeconomics explains even fluctuations as paths of intertemporal equilibrium. One can suspect some role, in this development, of that same "desire to bring consistency back into economic theory" (i.e. consistency with the accepted theory of value and distribution) which according to Garegnani (1983(1978), fn. 44 p. 60) "encouraged the attempts to confine the implications of Keynes's theory strictly to short-period analysis". In the first two decades after the publication of the *General Theory* the accepted theory of value and distribution was still the long-period (traditional) marginalist one, based on capital the single factor, and compatible with time-consuming disequilibrium adjustments (including aggregate fluctuations) because of the persistency (and independence from the accidents of disequilibrium) of the long-period equilibrium it determined; it was with this theory that Keynes's arguments had to be reconciled. Since then, the Cambridge controversies have forced the defensive

The puzzling thing is that the claimed consistency of this type of macro models with infinite-horizon General Equilibrium theory is announced with pride, as supporting the trustworthiness of these models, while on the contrary more and more often general equilibrium specialists reject the descriptive validity of GE theory. One can mention Michio Morishima, Stephen Marglin, Duncan Foley, Alan Kirman as at one time convinced (and highly esteemed) neoclassical theorists who have decidedly rejected GE theory. An implicit rejection also emerges in the fact that the problems with uniqueness and tâtonnement stability have

> led many microeconomists to forsake the general equilibrium conceptualization altogether. As a result, microeconomic theory has, by and large, been reduced to a collection of techniques and tricks for resolving narrow, isolated microeconomic problems and the study of, also narrow and isolated, strategic behaviors. (Katzner, 2006, p. ix)

But the problems with stability go beyond those of tâtonnement stability; Frank Hahn, Franklin Fisher, and many others have stressed the need for studies of the working of the 'invisible hand' allowing time-consuming adjustments including the implementation of disequilibrium decisions[37]; the descriptive validity of GE models is thereby implicitly questioned, because if time-consuming disequilibrium adjustments are allowed, the path of the economy becomes a problem on which GE theory is silent because it has no theory of time-consuming disequilibrium.

Also, many theorists are very uneasy with the assumption of complete futures markets or correct foresight. No less an authority than Roy Radner, in the entry "Uncertainty and general equilibrium" in the second edition of the *New Palgrave Dictionary of Economics*, admits an inability of intertemporal equilibria to have descriptive validity by stating that

> the perfect foresight approach ... is contrary to the spirit of much of competitive market theory in that it postulates that individual traders must be able to forecast, in some sense,

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retreat of neoclassical economists into claiming that the rigorous foundation of their approach is the neo-Walrasian versions of General Equilibrium theory. Then the desire for theoretical consistency obliges the macroeconomist to assume continuous (and instantaneously reached) equilibrium, because these modern versions of General Equilibrium theory determine equilibria devoid of persistency, incapable therefore of indicating the long-period trend of economies undergoing disequilibrium fluctuations.

[37] E.g. "I have always regarded Competitive General Equilibrium analysis as akin to the mock-up an aircraft engineer might build ... at no stage was the mock-up complete; in particular, it provided no account of the actual working of the invisible hand" (Hahn, 1981, p.1036); "In a real economy, however, trading, as well as production and consumption, goes on out of equilibrium ... 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 ... This path dependence makes the calculation of equilibria corresponding to the initial state of the system essentially irrelevant" (F. M. Fisher, 1983, p. 14). Franklin Fisher seems to be the only author to have dared admit disequilibrium productions in an economy with capital goods, but as I have noted in Petri (2004, ch. 2) his analysis reached no definite conclusion.

the equilibrium prices that will prevail ... it seems to require of the traders a capacity for imagination and computation far beyond what is realistic ... An equilibrium of plans and price expectations might be appropriate as a conceptualization of the ideal goal of indicative planning, or of a long-run steady state toward which the economy might tend in a stationary environment. (Majumdar and Radner, 2008, p. 444). [38]

The thoroughly destructive implications of such a statement must be stressed. Outside a stationary environment it is implausible to assume a perfect foresight equilibrium; even in a stationary environment the only non-implausible perfect foresight equilibrium is a steady-state one; therefore equilibrium paths *tending* to a steady state (and therefore different from steady states) are implausible; and since GE theory can only describe equilibrium paths, GE theory supplies no argument for believing in a tendency to the sole type of situation, a steady state one, where the notion of perfect-foresight equilibrium is not totally implausible.

The alternative of temporary equilibria without correct foresight, explored in the 1970s and early 1980s, is nowadays in total disrepute (as evidenced by its complete disappearance from advanced micro textbooks) owing to the problems its formalization encountered; which explains why Lucas or DSGE models only refer to intertemporal equilibria as their 'rigorous' microfoundation.

One might then reject DSGE models simply as a consequence of the rejection of intertemporal General Equilibrium theory as a positive theory, a rejection motivated – even leaving other difficulties aside – by this theory's need for the untenable assumption of complete markets or perfect foresight, and by its inability to study time-consuming adjustment processes, which implies an inability to say anything on the distance between equilibrium paths and the behaviour of economies not continually perfectly in equilibrium [39].

But, as I have argued elsewhere (Petri 1999, pp. 53-54), it is difficult to understand the acceptance of intertemporal equilibria as descriptively valid without a more or less conscious belief that the undeniable occurrence, in actual economies, of disequilibrium and time-consuming adjustments does not destroy the neoclassical theses as to the *trend* the economy follows, a trend which is believed to be reasonably approximated by the intertemporal equilibrium path. Only an idiot would deny that in actual economies there is no auctioneer and no complete futures markets, but rather time-consuming trial-and-error adjustments, mistakes, disequilibria, imperfect foresight; so

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[38] A very similar opinion is in Grandmont (1982, pp. 879-880). Completeness of futures markets clearly is the opposite of reality, so the criticisms only address the perfect foresight assumption. Christopher Bliss too has recently argued that the price paths of general equilibrium models "are essentially the dynamics of correctly-foreseen prices....We do not live in a world where price movements are accurately foreseen. Just look at the gyrations in the oil market in recent months to confirm this point." (Bliss 2009).

[39] A survey of these and other criticisms is in Petri (2011b). In particular on the last point cf. Petri (1999, p. 50) where the conclusion is reached that, once instantaneous equilibration is rejected, "neither the initial-period neo-Walrasian equilibrium nor the equilibrium path (if it can be determined) based on the initial data can tell us *anything at all* on the actual evolution of the actual economy, because no force exists in the theory, capable of limiting the initial deviation from equilibrium, or of preventing a cumulation of deviations over a number of periods, in real economies."

DSGE theorists must believe that actual economies are not all the time in equilibrium, there is in fact continuous error-correction, discovery of novelties, discrepancies between supply and demand on the several markets, *but* there are persistent forces that cause these disequilibria to be sufficiently corrected or compensated so that the trend the economy actually follows is not too far from the path described by their continuous-equilibrium models[40]. The intertemporal equilibrium is then only a rough indication of the average trajectory of the actual economy, which is never completely in equilibrium. Behind the reference to modern, neo-Walrasian intertemporal general equilibrium theory as the microfoundation of the macro models there must therefore be a much more traditional and much less absurd position than the belief that the economy is actually continually perfectly in intertemporal equilibrium in all markets: namely, a belief that the assumption of continuous equilibrium does not do *excessive violence* to the description of actual economic behaviour, because the tendency toward full employment, toward equality between supply and demand on the several markets, and toward income distribution determined by marginal products, does exist in reality although it is far from ultrafast, and it causes the behaviour of the economy to be not too far from what it would be with continuous equilibrium. But then the reference to disaggregated intertemporal equilibrium with perfect foresight as the 'rigorous' microfoundation of the models is only a smokescreen, behind it there is in fact a belief in the *time-consuming* adjustment mechanisms on whose basis the marginal approach was born and accepted, the mechanisms that after Keynes were rehabilitated by monetarism carrying forward from the criticism of Keynes initiated by the

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[40] Some such view is for example implicit in the admissions by Lucas, Sargent and others that rational expectations make sense only for situations sufficiently persistent for agents to have had the time to learn how correctly to form their expectations – with the implication that, during the learning, mistakes and hence disequilibria are inevitable. For example: "decision rules are continuously under review and revision; new decision rules are tried and tested against experience, and rules that produce desirable outcomes supplant those that do not ... We use economic theory to calculate how certain variations in the situation are predicted to affect behavior, but these calculations obviously do not reflect or usefully model the adaptive process by which subjects have themselves arrived at the decision rules they use. Technically, I think of economics as studying decision rules that are steady states of some adaptive process, decision rules that are found to work over a range of situations and hence are no longer revised appreciably as more experience accumulates" (Lucas, 1986, p. S401-402); "rational expectations models impute much *more* knowledge to the agents within the model (who use the equilibrium probability distributions in evaluating their Euler equations) than is possessed by an econometrician, who faces estimation and inference problems that the agents in the model have somehow solved. ... Rational expectations is an equilibrium concept that at best describes how such a system might eventually behave if the system will ever settle down to a situation in which all of the agents have solved their 'scientific problems'" (Sargent, 1993, p. 23). Indeed decisions rules cannot but be "continuously under revision", if for no other reason because learning can never finish owing to the continuous emergence of novelties (technical progress, changes in tastes, new marketing ideas, discovery of new oil deposits, etc.); therefore these admissions imply that in most markets the equilibrium price often changes unpredictably and must be *found* again and again by trial and error, so disequilibria in the several markets cannot but be frequent, a fact that can only be neglected if one looks at trends of the averages and one assumes that time-consuming adjustments are in operation, which cause the trends to be sufficiently close to the equilibrium path.

neoclassical synthesis. Without some such belief *the reference to intertemporal equilibria would be devoid of any justification*, given that by themselves neo-Walrasian equilibria and their sequences tell us *nothing at all* about the actual path a market economy not continuously in equilibrium will follow.

For this reason, the arguments of the present paper are relevant criticisms of DSGE models too, as well as of the whole development of neoclassical macroeconomics after Keynes. The characterization of contemporary neoclassical macro models as simplified intertemporal general equilibrium models would, if taken seriously, deprive these models of any pretence to descriptive validity; such a pretence can only rely on traditional neoclassical macroeconomic tendencies, that is, on the same time-consuming adjustment mechanisms on which J. B. Clark or Wicksell or Pigou or Hayek, or the 'neoclassical synthesis' and monetarism, based their analyses, mechanisms based on traditional capital-labour substitution. The relevance of the argument of the present paper lies then in its pointing out that, the moment the continuous full employment of labour is not assumed to start with, those adjustment mechanisms will not work as usually presumed, and Say's Law loses credibility even before one questions the neoclassical conception of capital-labour substitution: this was not realized because the correct implications of that conception of capital for investment theory when labour employment is not given were not grasped. The recuperation of pre-Keynesian views initiated by the neoclassical synthesis and carried forward by monetarism, which is what lies behind the current faith in DSGE models, was made possible by a theory of investment which was mistaken not only in its foundation on an untenable conception of capital, but even if that conception is not questioned.

APPENDIX 1. *On Heijdra and van der Ploeg (2002).*

Like in earlier contributions to the adjustment-costs literature, this textbook presents the adjustment-costs approach to investment under an assumption "that the prices of goods and labour (P, P^I, W) have no time index, because we assume that firms expect these to be constant over time" (p. 40). Therefore whether the firm intends to expand or not its initial capital stock depends exclusively on whether those prices plus the rate of interest generate an average cost of production greater or less than the given product price *P*. (Thus once more we find the absurdity of a product price expected never to change even when considerably different from its average cost.) If the average cost of production is less than *P*, the firm wants to expand indefinitely, the speed of expansion being limited only by adjustment costs; no demand-side or labour-supply constraint is considered. It is mysterious, then, how five pages later the authors can argue that this theory of aggregate investment makes it dependent on the rate of interest, on the initial stock of capital, *and on aggregate output,* cf. equation (2.37) p. 45: *I=I(R,K,Y)*. Output *Y* had played no determining role at all in the previous analysis! It is only because of this unjustified jump to a different theory that the authors can then argue that the accelerator "may be seen as a special case of this general functional form for investment" (*ibid*.). Still, having now admitted an influence of *Y* upon investment, interestingly they proceed to admit on the next page that the stability of the *IS-LM* equilibrium is not guaranteed, because e.g. a decrease of the interest rate caused by an increased supply of money by stimulating investment causes a rise of *Y*, which further stimulates investment, possibly overpowering the disincentive to investment coming from the accompanying increase of the interest rate. But no attempt is made to discuss further

implications of such an observation, e.g. multiplier-accelerator models. And on the likelihood of instability the authors only state that "One finds stable adjustment processes as long as the investment lag is long enough and the propensity to consume small enough" (p. 58), a statement that makes the possibility of instability far from remote; so their statement a few lines earlier that instability "typically" does not arise appears unwarranted.

APPENDIX 2. *A mistake in Romer's expressions (8.6) and (8.7) for discounted profits.*

Romer's description of $\pi(K)k–I–C(I)$ as representing the profits at a point in time (a description that he takes from previous literature) is unacceptable: the expenditure $I_t + C(I_t)$ is *not* a *reduction* of the profits obtained at time t, it is an *investment* permitted by an increase of indebtedness or use of own funds, that, by causing subsequent interest payments (actual, or as opportunity costs), affects profits of time t+1 and afterwards, *not* those of time t. It is perhaps this improper definition of profits that has caused a mistake in the determination of profits in this literature, a mistake – accepted in Romer's (8.7) and (8.6) – which does not fundamentally vitiate the analysis but is still worth pointing out because surprisingly it seems to have never been noticed. The mistake is clearest if one considers a firm producing corn, with corn seed (circulating capital) and labour as inputs, in production cycles lasting one period, with wages paid at the end of the period and corn seed bought at the beginning of the period with borrowed money. Land is free; corn output and corn seed both have price 1. Suppose gross corn output Q_t (t=0, 1, ...) is obtained with the use of (i) labour which, since its wages are paid at time t, can be indicated as L_t, (ii) corn seed K which, being bought and paid one period before the output comes out, can be indicated as K_{t-1}. In this case it is easier than with indestructible capital to determine the profits associated with the output of a period, because each production cycle is independent of the previous and of the next one. Assuming absence of adjustment costs, the profits of the production cycle that produces output Q_t are given by

$Q_t - wL_t - (1+r)K_{t-1}$.

In discounted terms this becomes

$[Q_t - wL_t - (1+r)K_{t-1}]/(1+r)^t = [Q_t - wL_t]/(1+r)^t – K_{t-1}/(1+r)^{t-1}$.

With adjustment costs, the discounted cost of buying the quantity K_{t-1} of corn seed is K_{t-1} plus the appropriate adjustment cost C_{t-1}, both discounted by division by $(1+r)^{t-1}$; therefore *for t≥1* one can re-arrange the infinite sum yielding the discounted profits so that each discount factor $1/(1+r)^t$ multiplies $Q_t - wL_t - K_t - C_t$, which is what Romer would illegitimately call the profits of period t for this example. This also shows that Romer's representation (p. 371) of the firm's profits "neglecting any costs of acquiring and installing capital" as $\pi(K_t)\cdot k_t$ in (8.7) and (8.6) would correspond, for this example, to $Q_t - wL_t$. That this induces error is shown by the fact that for t=0 the correct expression derived with the rearrangement is *not* $Q_0 - wL_0 - K_0 - C_0$, it is $Q_0 - wL_0 - (1+r)(K_{-1}+C_{-1}) - K_0 - C_0$, because the actual profits from the production of Q_0 are $Q_0 - wL_0 - (1+r)(K_{-1}+C_{-1})$: profits correctly defined for period 0 require that one subtracts from Q_0 not only wL_0 but also the payment of gross interest on the corn seed bought at time –1 and on the adjustment costs borne at time t-1 so as to produce Q_0.

Romer's (8.7) differs from this example because it assumes indestructible capital, increased

by investment. Then a unit of investment or of adjustment cost at time t can be imagined as paid with borrowed money and therefore causing no cost at time t, but causing the payment of interest r each period from t+1 for the infinite future; this series of payments, discounted to t, has value 1; therefore I_t+C_t represent the discounted value at t of the infinite series of interest payments caused by the purchase of I_t+C_t; hence $(I_t+C_t)/(1+r)^t$ is the discounted value at t=0 of these payments. Imagining again wages and interest to be the only payments to factors, and the output to consist of a quantity of a single good with price 1, the discounted value of profits is therefore

$$\left[\sum_{t=0}^{\infty}Q_t - wL_t - I_t - C_t\right] - (1+r)(k_0 + \tilde{C}_0).$$

The terms outside the square brackets are missing in Romer. Romer's mistake, inherited from previous treatments of the argument, is that he forgets that since the firm is assumed to start with an initial capital stock k_0, *a debt must correspond to it* which causes interest payments from t=0 onwards that must be subtracted from revenue in order to obtain the true profits. The discounted value of these interest payments forgotten by Romer (and by previous literature) is what appears outside the square brackets: k_0 is the cumulated past investment $I_{-1}+I_{-2}+...$ that created that capital stock; the corresponding debt causes a series of interest payments from t=0 onwards of value, discounted *to t=-1*, equal to k_0, so to obtain its value discounted to t=0 one must multiply it by (1+r); $\tilde{C}_0$ is the cumulated value of the adjustment costs borne in the past by the firm to build up that capital stock, again causing a flow of interest payments of discounted value at t=-1 equal to $\tilde{C}_0$, a value unfortunately not derivable from the observation of k_0 because depending on the speed with which k_0 was accumulated. If we indicate $(1+r)(k_0 + \tilde{C}_0)$ as D, initial debt, then the true discounted value of profits is not the $\tilde{\Pi}$ determined by Romer's expression (8.7) but rather $\tilde{\Pi}-D$. For example, if the firm keeps its initial capital unchanged from period to period, and therefore makes no investment and has no adjustment costs, and has made no investment in the past, then Romer's own definition of profits on p. 367 as $\pi(K, X_1, X_2,...,X_n)-r_K K$ implies that one should subtract each period from π (here standing for the total amount, *not* per unit of capital) the payment of interest on K, but this payment does not appear in (8.7).

If the analysis is in continuous time, with continuous flow production, and continuous payment of a flow of wages and of an instantaneous rate of interest *r* on indestructible capital, the picture is essentially the same and I leave it to the reader to go through the corresponding steps in this case; the conclusion is the same, Romer's (8.6) and the analogous literature forget that there is a capital k_0 the firm already owns at time zero, which causes a flow of interest payments over the infinite future, of a discounted value equal to the value of that capital. Therefore if for simplicity we assume zero adjustment costs, (8.6) needs the following correction: the true present value of profits is not what Romer indicates as Π, but rather $\Pi-k_0$.

(The mistake would not arise if one could assume that the firm starts with a zero stock of capital, but this is not and cannot be the assumption made in the adjustment costs literature, which must explain investment in economies where there is already a stock of capital goods.)

Since in either case the correction requires the subtraction of a given constant, the first-order conditions for (interior) maximization are not altered by the error, but the determination of when the present value of profits becomes negative and the firm goes bankrupt *is* affected.

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