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ALESSANDRA PELLONI

European University Institute, Florence

EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

ECONOMICS DEPARTMENT

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ALESSANDRA PELLONI

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European University Institute
Badia Fiesolana
I – 50016 San Domenico (FI)
Italy

Nominal Rigidities and Increasing Returns

Alessandra Pelloni*

Economics Department, European University Institute,
Florence, and
Facoltà di Economia e Commercio, Università di Sassari,
Italy

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Abstract

The paper proposes a simple model of wage setting and imperfect competition that takes into account knowledge and human capital accumulation. We show that, given increasing returns to reproducible factors, transitory disturbances to output that originate on the demand side of the economy produce permanent upward shifts in the aggregate production function.

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1 Introduction

In this paper we introduce an explicit production technology into a business cycle model with nominal rigidities and in particular consider the effects of demand disturbances, given increasing returns in the production of accumulable factors. As is well known, increasing returns in human and physical capital have represented the main mechanism in the recent wave of growth models. These however assume perfectly flexible prices thus ruling out the possibility of disequilibrium unemployment, on which we now focus. A related question we ask is whether this kind of analysis can cast any light on empirical evidence from, for instance, Nelson and Plosser (1982) and Campbell and Mankiw (1987), that the trend component of an economy's GNP includes a substantial random element. These findings have undermined traditional views of the business cycles according to which fluctuations are primarily driven by nominal disturbances that do not alter the long-run performance of the economy. Real business cycle models, which are based on the neoclassical growth model, generate a stochastic trend in output if the process governing the Solow residual contains a unit root.[1] We consider instead the possibility that also transitory nominal shocks have permanent effects if growth mechanisms are taken into account. King, Plosser and Rebelo (1988) have already pointed out similar results for technology shocks and Bean (1990) for fiscal shocks. Path-breaking papers in this direction of research are Stadler (1986) and (1990). He shows using a model of wage setting the possibility that when technology is endogenous through "learning by doing" there is long-run non-neutrality of money. Since he works in a perfect competition framework he has to to assume that knowledge is a pure public good, i.e. not only non-rival but also totally non-excludable. Moreover the way in which he models the supply-side of the economy technology implies an explosive or (implosive) process for per capita income. The specification of the supply-side of the economy proposed below, closer to the conventions of the new growth theory, avoids these shortfalls and makes clear the importance of constant returns in capital accumulation as a propagation factor due to which transitory nominal disturbances may have permanent effects. In other words we show that the same conditions on the accumulation of factors that deliver long-run growth in a deterministic environment imply hysteresis in the process for income in a stochastic environment if prices are not perfectly flexible, even in the absence of technological shocks. This shows that findings of a unit root

[1] See, for instance, Kydland and Prescott (1982), Long and Plosser (1983), King and Plosser (1984) and Prescott (1986).

in the process for income may say very little about the forces driving the cycle.

2 The Model

We formalize our argument by means of a simple model of wage setting and imperfect competition, in the Gray-Fischer-Blanchard-Summers line.[2] Nominal wages are generally set by contracts in unionized sectors so they cannot adjust quickly when economic conditions change and in even in industries not covered by formal contracts, implicit agreements between workers and firms may limit wage changes. The "right to manage assumption", whereby firms treat wages as predetermined (although possibly the outcome of bargaining) and choose the level of employment unilaterally, rules out "efficient bargains" where there is bilateral bargaining between workers and management over employment.[3] However most unemployment researchers have assumed that the phenomenon is relatively unimportant at the aggregate level.[4] Card (1988) points out that the weak aggregate correlation between employment and real wage, often cited as evidence against simple wage setting , monopoly union models, may be due to a simultaneity bias, arising from the fact that the two variables are jointly determined in the labour market.[5]As is well known the persistence of unemployment will be increased if contracts are staggered;[6] however here we stick to the simplest case of contracts lasting just one period.

Firms and workers are assumed to know the structure of the model and the distribution of the innovation terms that enter the model and to form expectations that fully reflect that knowledge. The aggregate economy is composed of n monopolistically competitive firms. Uncertainty enters in the form of aggregate demand disturbances that affect all industries identically.

Each firm maximizes its stream of discounted expected profits:

[2]See Gray (1976), Fischer (1977) and Blanchard and Summers (1986).

[3]This insight is due to Leontief (1946). McDonald and Solow (1981) have shown that the locus of efficient contracts lies on the left of the labour demand curve with the two curves meeting at the workers' reservation wage.

[4]See, among others, Brown and Ashenfelter (1986) and McCurdy and Pencavel (1986).

[5]In particular the estimate will be biased when the parties involved in the contract are better able to forecast employment than an outside observer. Card finds for the Canadian manufacturing sector that when unanticipated real wage changes are used as an instrumental variable for contract wages employment is systematically negatively related to wages. He also finds no evidence that employment determination is related to outside wage rates in a manner consistent with simple models of efficient contracting.

[6]See Taylor (1979).

$$V = \max_{\{L_t^i, K_t^i\}} E\left[\sum_{j=0}^{\infty} \theta^j \left(P_{t+j}^i Y_{t+j}^i - W_{t+j}^i L_{t+j}^i - r_{t+j} K_{t+j}^i\right) | \, I_t\right] \tag{1}$$

where L_t^i is employment by firm i, hired at the rental rate W_t^i, P_t^i the price at which it sells its product Y_t^i and r_t is the rental rate of capital K_t. The notation $E[\cdot|\ I_t]$ denotes the expectation conditional on information available at time t, I_t. At time t, the demand facing each firm is given by:

$$y_t^i = -\omega(p_t^i - p_t) + (m_t - p_t) \tag{2}$$

here and in what follows lowercase letters indicate logarithms. m_t is the logarithm of the stock of nominal money and p_t the logarithm of the general price index defined as:

$$P_t \equiv n^{\frac{1}{\omega-1}} \left(\sum_{i=1}^{n} (P^i)^{1-\omega}\right)^{\frac{1}{1-\omega}} \tag{3}$$

ω is the constant elasticity of substitution between goods; when it goes to infinity we obtain the perfect competition case.The demand for each good can be derived assuming a quantity theory of money or a Clower constraint and the same CES index for consumption and investment.[7]

The utility function of each household (whose number is normalized to be equal to the number of firms) depends on C defined as:

$$C = n^{\frac{1}{1-\omega}} \left(\sum_{i=1}^{n} (C^i)^{\frac{\omega-1}{\omega}}\right)^{\frac{\omega}{\omega-1}} \tag{4}$$

where we have suppressed the household's index, since all households are identical and where C^i is the purchase of the ith product as a consumption good.

The effect of investment on the accumulation of physical capital K_t is given by:

$$K_t = K_{t-1} + I_{t-1} \tag{5}$$

where

$$I = n^{\frac{1}{1-\omega}} \left(\sum_{i=1}^{n} (I^i)^{\frac{\omega-1}{\omega}}\right)^{\frac{\omega}{\omega-1}} \tag{6}$$

[7]See Blanchard and Kiyotaki (1987) and Kiyotaki (1988).

and where I^i is the purchase of the ith product as an investment good.

Each firm operates with the same Cobb-Douglas technology:

$$y_t^i = \mu k_t^i + \beta l_t^i + \psi k_t + \eta a_t \tag{7}$$

where a is human capital, defined as labour quality, assumed to be equal for all workers, and the paramater ψ captures the external effects from average physical capital.[8] The assumption of imperfect competition allows us to consider the case of increasing returns at the firm level, for instance $\mu \geq 1$, whose implications for growth will be considered later.[9] The absence of costs of adustment in the use of factors makes it possible to treat the firm's problem like a one-period problem. From profit maximization and ignoring constants, here and in what follows, the following expression for labour demand can be obtained:

$$l_t^{i,d} = \frac{-w_t^i + \frac{m_t}{\omega} + (1 - \frac{1}{\omega})(p_t + \mu k_t^i + \psi k_t + \eta a_t)}{1 - \beta(1 - \frac{1}{\omega})} \tag{8}$$

Each firm is in a bargaining relationship with $\underline{L}$ workers and $\underline{L}$ is assumed fixed. The nominal wage is set one period in advance. The full information level of employment is assumed to be fixed at the level L^*. Workers want to minimize the mean squared deviation of the logarithm of employment from its target level. Their problem is:

$$\min_{w_t} E\left[(l_t - l^*)^2 \mid I_{t-1}\right]$$

under the constraint represented by equation 8. Since the problem is a linear quadratic one its solution exhibits the certainty equivalence property, i.e. the nominal wage is set at the level implying that expected employment $E[L_t \mid I_{t-1}]$ is equal to L^*. So eliminating expected employment in firm i from 8 we obtain:

$$\begin{aligned} w_t^i = \frac{E[m_t|I_{t-1}]}{\omega} + (1 - \frac{1}{\omega})(E[p_t|I_{t-1}] + \mu k_t^i + \psi k_t + \eta a_t) \\ -(1 - \beta(1 - \frac{1}{\omega}))l^* \end{aligned} \tag{9}$$

Assuming equality betwen individual and average stocks of physical capital we then have $w_t^i = w_t$, $l_t^{i,d} = l_t^d$. Substituting the expression for l_t^i from equation

[8] In human capital models, for instance in Lucas(1988), externalities from human capital are often considered. However since in the present model human capital is not a separately traded factor of production to introduce them would not change the analysis.

[9] The condition for the non-negativity of equilibrium profits is in fact $\mu \leq \frac{\omega}{\omega - 1} - \beta$.

8 in equation 7, the resulting expression for y_t^i in equation 2 and solving for p_t^i one gets:

$$p_t^i = \frac{\left((1-\frac{1}{\omega})p_t + \frac{m_t}{\omega}\right)(1-\beta) + \frac{1}{\omega}\left(\beta w_t - (\mu+\psi)k_t - \eta a_t\right)}{1-\beta(1-\frac{1}{\omega})} \tag{10}$$

which makes clear that $p_t = p_t^i$, so that:

$$p_t = (1-\beta)m_t + \beta w_t - (\mu+\psi)k_t - \eta a_t \tag{11}$$

From this it is clear that the real cost of capital will be the same for all firms so that the assumption of each firm hiring the same amount of capital is warranted. From equations 8 and 11, we then get:

$$l_t^d = m_t - w_t \tag{12}$$

From equation 12 and the wage rule one infers that:

$$w_t = E[m_t|I_{t-1}] - l^* \tag{13}$$

Hence:

$$l_t = m_t - E[m_t|I_{t-1}] + l^* \tag{14}$$

Finally, the money supply is assumed to follow a random walk with positive drift. The drift is set by the central bank so as to avoid an ongoing deflation in a growing economy, given a constant velocity of money. The money supply rule is public knowledge. This is:

$$m_t = m_{t-1} + \pi + \epsilon_t \tag{15}$$

where the disturbance term ϵ is a zero-mean stochastic error with constant variance.

Substituting the expression for l_t given by equation 14 in the production function, after calculating the forecast error from equation 15, the following process for income is derived:

$$y_t = \beta(\epsilon_t + l^*) + (\mu+\psi)k_t + \eta a_t \tag{16}$$

So output depends on the level of physical and human capital and on technology, as well as on the full information level of employment. A positive value of ϵ_t raises output as in all demand-side models of the business cycle with nominal wage contracting because it causes the price level to rise above its expected value and hence depresses the real wage increasing labour demand.

3 Long run Growth

We now come to the accumulation of factors of production. We first consider Stadler (1990), who endogenizes the growth process, introducing learning by doing not appropriable at the firm level in a perfect competition wage setting monetary model of the business cycle. He posits the following production technology:

$$Y_t^i = (L_t^i)^\alpha Z_t^{1-\alpha} \tag{17}$$

$$0 < \alpha < 1$$

Z_t is a scale factor that represents accumulation of technical knowledge, which is assumed to evolve according to:

$$Z_t = Z_{t-1} \left[\frac{Y_{t-1}}{L_{t-1}} \right]^\lambda (L_{t-1})^\gamma \tag{18}$$

$$0 < \lambda, \gamma < 1.$$

The evolution of technical knowledge therefore depends on the level of aggregate labour input and aggregate labour productivity in the previous period. The first effect is due to the fact that the greater the level of labour input the greater the scope for learning and the acquisition of new skills. The second captures the persistence in productivity gains independent of changes in labour input for example through reorganization of the production process and firm structure to achieve greater efficiency. By substituting equation 17 in equation 18 one obtains:

$$\frac{Z_t}{Z_{t-1}} = Z_{t-1}^{\lambda(1-\alpha)} L_{t-1}^{\lambda(\alpha-1)+\gamma} \tag{19}$$

The problem with this formulation is that equation 19 may imply explosive growth.[10] Stadler invokes two possible solutions to this problem. The first is to assume, in equation 18, a coefficient on Z_{t-1} equal to $1-\delta$, where δ is the rate of technology depreciation; explosive growth is then ruled out if $\delta = \lambda(1-\alpha)$. However this is clearly somewhat arbitrary. Alternatively he assumes a backward-bending labour supply: $L^s = (W/P)^\phi, \phi < 0$. This implies the following expression for the market-clearing level of employment:

$$L_t^* = \alpha^{\frac{\phi}{1+\phi(1-\alpha)}} Z_t^{\frac{\phi(1-\alpha)}{1+\phi(1-\alpha)}} \tag{20}$$

which, substituted in equation 19, allows one to write it as:

$$\frac{Z_t}{Z_{t-1}} = \alpha^{\frac{\phi(\gamma-(1-\alpha)\lambda)}{1+(1-\alpha)\phi}} Z_{t-1}^{\frac{(1-\alpha)(\lambda+\phi\gamma)}{1+\phi(1-\alpha)}} \tag{21}$$

so that, what is needed in this case is that $\lambda = -\phi\gamma$. However the problem is that asymptotically employment will reach either its lower bound or its upper bound depending on whether $1+\phi(1-\alpha)$ is positive or negative.

The following alternative does not suffer from these limitations and makes it easier to relate the analysis to the literature on growth. I consider a transition equation for human capital based on a Cobb-Douglas technology:

$$\frac{A_t^i - A_{t-1}^i}{A_{t-1}^i} = (L_{t-1}^i)^v L_{t-1}^\zeta (A_{t-1}^i)^{\vartheta-1} A_{t-1}^\xi (K_{t-1}^i)^\chi K_{t-1}^v - \delta_1 \tag{22}$$

where δ_1 is the rate of depreciation. While in Lucas (1988) human capital is accumulated through formal schooling, here a different effect is at work, i.e. that having worked in the past makes workers more productive, as happens when there is "on the job training". The importance of such effects is often emphasized in labour economics, especially with regard to the disenfranchisement of long-term unemployed from the effective labour force and the related possibility of hysteresis in the natural rate of unemployment. Notice that, in offering labour, workers would in general take into account the increase in their human capital that being involved in production brings about, abstracting from external effects on labour.[11] By symmetry, equation 22 can be written as:

$$\frac{A_t - A_{t-1}}{A_{t-1}} = L_{t-1}^{\zeta+v} A_{t-1}^{\xi+\vartheta-1} K_{t-1}^{v+\chi} - \delta_1 \tag{23}$$

[10] This criticism is due to Aghion and Saint-Paul (1993).

[11] In fact if we had assumed a unified labour market equilibrium employment would have been higher through this channel.

Coming to the accumulation of physical capital, we make the solovian behavioural assumption that the ratio of investment to income, s, is constant. We then have:

$$\frac{K_t - K_{t-1}}{K_{t-1}} = sL_{t-1}^{\beta} A_{t-1}^{\eta+\gamma} K_{t-1}^{\mu+\psi-1} - \delta_2 \tag{24}$$

As regards capital accumulation we have a different form of "learning by doing", closer to the one developed in Arrow (1962) and Sheshinski (1964) and revived in Romer (1986) who assume that technical progress is a by-product of producing and in particular of investing. These authors all assume perfect competition. Dasgupta and Stiglitz (1987) notice however that "learning by doing" is consistent with perfect competition only on the unplausible condition that not even a fraction of the accumulation of knowledge that goes with the accumulation of capital can be appropriated at the firm level. In fact, otherwise, assuming constant returns to scale as regards the rival factors, which is a consequence of the principle of replication, if factors were paid their marginal productivity, profits would be negative. This makes it advisable to assume instead imperfect competition. Another way to look at the issue is to assume that part of the payments to capital are in fact R&D expenditures and that there is a fixed ratio between the stock of capital and the stock of technical ideas.[12]

In steady state monetary shocks do not impinge on the economy, as expectations are realized, $L_{ss} = L^*$.

As can be seen by second-order differencing of a_t and k_t, for A and K to grow at a constant rate we need:

$$0 = (L^*)^{\zeta+\upsilon} A_{t-1}^{\xi+\vartheta-1} K_{t-1}^{\upsilon+\chi} \left(1 - \frac{(1+g_a)^{1-\xi-\vartheta}}{(1+g_k)^{\upsilon+\chi}}\right) \tag{25}$$

$$0 = s(L^*)^{\beta} A_{t-1}^{\sigma+\eta} K_{t-1}^{\mu+\psi-1} \left(1 - \frac{(1+g_k)^{1-\mu-\psi}}{(1+g_a)^{\sigma+\eta}}\right) \tag{26}$$

If $g_a = g_k = g$, the rate of balanced growth, is to be strictly positive, it must be that:

$$1 - \xi - \vartheta = \chi + \upsilon, 1 - \mu - \psi = \sigma + \eta \tag{27}$$

[12]The idea that the future productivity of the economy is adversely affected by economic downturns because of reduced expenditures on R & D is developed in Stiglitz (1993).

This the usual condition of constant returns to scale to the producible factors in their own production. If $\delta_1 = \delta_2 = \delta$ it is possible to get a closed form for the steady-state rate of growth. This is:

$$g = -\delta + (L^*)^{\frac{\beta(\upsilon+\chi)+(\zeta+\nu)(\sigma+\eta)}{\upsilon+\chi+\sigma+\eta}} s^{\frac{\upsilon+\chi}{\upsilon+\chi+\sigma+\eta}} \tag{28}$$

This shows that the rate of saving and the equilibrium level of employment are positively related with the rate of growth, while the rate of depreciation is negatively related to it.[13]

4 From the Short to the Long-Run

To study the transitional dynamics we will have to resort to some simplifying assumptions, in fact considering two different models nested in the general one used for steady state analysis.

In the first model, as is in the Arrow-Sheshinski-Romer tradition, human capital does not enter the production function, i.e. $\eta = 0$

Now consider the hypothesis that the "learning by doing" effect is not so strong as to deliver constant returns to scale to the accumulable factor. This implies that $\mu + \psi < 1$. The steady-state level of physical capital is:

$$K^1_{ss} = \left(\frac{s(L^*)^\beta}{\delta_2} \right)^{\frac{1}{1-\psi-\mu}} \tag{29}$$

We will show that given these assumptions on technology, an innovation in the process governing money supply cannot have permanent effects. Suppose, for instance, that, starting from a situation of steady-state equilibrium, we have at time t a positive forecast error, so that $L_t > L^*$. To isolate the effect of this single shock, let us assume that in all subsequent periods expectations are realized, i.e. $L_s = L^*$ for all $s > t$. But then there will be a positive net

[13]This is true even with different rates of depreciation as can be seen by considering the following equation in g:

$$g + \delta_2 = \frac{s(L^*)^{\frac{\beta(\upsilon+\chi)+(\zeta+\nu)(\sigma+\eta)}{\upsilon+\chi}}}{(g+\delta_1)^{\frac{\sigma+\eta}{\upsilon+\chi}}}$$

We have on the left-hand side of the equation a linear function of g and on the right-hand side a hyperbola. By analysing how the intersection between the two curves moves when the values of the parameters change the conclusion follows.

investment, i. e. $K_{t+1} > K_t = K_{ss}$, since, from equation 24, and considering equation 29:

$$sL_t^{\beta} K_{ss}^{\mu+\psi-1} - \delta_2 > 0 \tag{30}$$

However subsequently capital will decumulate, since the same equations imply for $K_s > K_{ss}$:

$$s(L^*)^{\beta} K_s^{\mu+\psi-1} - \delta_2 < 0 \tag{31}$$

The reduction in the stock of capital will go on until the stationary-state level is reached again, with a velocity of convergence depending on parameters.

Now consider instead the case of constant returns. Equation 24 can then be rewritten, approximating:

$$k_t = k_{t-1} + sL_{t-1}^{\beta} - \delta_2 \tag{32}$$

but since from equation 7 we have:

$$k_{t-1} = y_{t-1} - \beta l_{t-1} \tag{33}$$

we obtain, substituting in equation 16, the following data generating process for income:

$$y_t = y_{t-1} - \delta_2 + \beta(\epsilon_t - \epsilon_{t-1}) + s(L^*)^{\beta} \exp \beta \epsilon_{t-1} \tag{34}$$

The process is integrated of order one and the structure of the error term is such that shocks will have permanent effects. This is clear by considering the impulse response function:

$$y_t = y_0 + -\delta_2 t + \beta(\epsilon_t - \epsilon_0) + s(L^*)^{\beta} \sum_{i=0}^{t-1} \exp \beta \epsilon_{t-i} \tag{35}$$

In the second particular case it is the role of physical capital to be abstracted from, as done in Stadler (1990), i.e. $\mu + \psi = 0$ and $\chi + \upsilon = 0$. If $\xi + \vartheta < 1$, the steady- state level of human capital will be:

$$A_{ss}^2 = \left(\frac{(L^*)^{\upsilon+\zeta}}{\delta_1} \right)^{\frac{1}{1-\xi-\vartheta}} \tag{36}$$

If we start with this stock of human capital any shock raising employment above the full information level will push the stock above the steady-state value.

However this over-accumulation will subsequently be undone, unless further shocks occur in the same direction of the first.

Again for long-run growth we need constant returns to scale. i.e. $\omega+\vartheta = 1$. Through manipulations analogous to those just described we again get a unit root process for income:

$$y_t = y_{t-1} - \delta_1 + \beta(\epsilon_t - \epsilon_{t-1}) + (L^*)^{\zeta+v} \exp(\zeta + v)\epsilon_{t-1} \tag{37}$$

and

$$y_t = y_0 - \delta_1 t + \beta\,(\epsilon_t - \epsilon_0) + (L^*)^{\zeta+v} \sum_{i=0}^{t-1} (\zeta + v) \exp \beta\epsilon_{t-i} \tag{38}$$

So it is clear from the analysis of both models that "learning by doing" , when it is not strong enough to avoid decreasing returns can deliver persistence not hysteresis. The following assertion by Stadler (1990) is therefore somewhat too general. He writes: "when technology is dependent on demand conditions, monetary shocks have a permanent impact on output. There is a long-run non-neutrality of money in models with endogenous technology". However I have shown that endogeneity per se is not sufficient to get the result.

On the other hand, when the condition for unbounded accumulation holds, i.e. the presence of non decreasing returns to the producible factors, nominal demand disturbances will have permanent hysteretic effects, through their influence on the supply-side of the economy. In fact output is a difference-stationary process that depends upon the sum of all past monetary misperceptions.

In our approach to the study of the interactions between growth and business cycles, recessions have therefore negative long-run effects on productivity. Some recent theoretical papers have instead revived the "schumpeterian" view of recessions as providing a mechanism for reducing resource misallocations so they have a long-run positive effect on productivity. Caballero and Hammour (1991) have used a model of "creative distruction" to show that economic downturns have cleansing effects on outdated techniques and products. Hall (1991) has emphasized the role of "organizational capital", whose accumulation would increase during a slump. These and other studies (see the survey by Aghion and Saint-Paul 1993) rely on intertemporal substitution of productivity increasing activities, whose opportunity cost falls during a recession. We wish to underline that the two views, the "kaldorian" and the "schumpeterian", are not incompatible in the sense that a recession may have both positive effects on

productivity through reorganization efforts etc., and negative effects, through reduced "learning by doing", "on the job training" etc. The question of which kind of effects prevail is in fact an empirical one and the evidence so far is mixed. Gali and Hammour (1993) and Saint-Paul (1993) using economy-wide data have found that the long-run response of productivity to demand shocks is negative, which supports the "schumpeterian" view. Jiménez and Marchetti (1994), using a panel data set of 402 four-digit U.S. manufacturing industries find, on the contrary, that such response is positive or positively close to zero depending on the industry.[14]We can conclude that both views deserve therefore further investigation theoretically and empirically.

5 Concluding Remarks

The possibility that demand shocks have permanent effects contradicts a long tradition in macroeconomic theory: fluctuations in economic activity are generally studied in a "short term" framework in which the capital stock and productivity are kept constant. Conversely the supply of capital and labour play the central role in understanding growth, but inflation and short term demand disturbances are ignored. The above separation is removed in Stadler (1986) and (1990). The present paper has proposed a monetary, imperfect competition model of the business cycle, in which knowledge accumulation internal and external to firms is taken into account. The specification of the technology avoids some limitations and counterfactual implications of Stadler's models, regarding in particular the appropriability of knowledge and the explosive character of growth. Furthermore, being in the mould of most endogenous growth models, makes it easier to clarify the link between the conditions for endogenous growth and hysteresis in per capita income.

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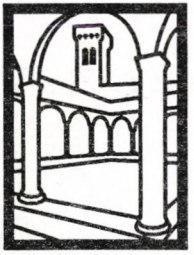

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