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A Business Cycle Model Based on Efficiency Wages, Monopolistic Competition and Nondecreasing Returns

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A model is analyzed in which workers' efforts depend positively on the real wage and the unemployment rate. Due to isoelastic demand and constant marginal cost it is optimal for firms to set the output price as a fixed markup over the nominal wage. When demand shocks occur, firms' first response is therefore to adjust output and employment. But as the unemployment rate changes, the efficient real wage changes too. This causes firms to adjust their nominal wages and prices which in turn implies a revision of labour input and goods output. The resulting dynamics is capable of generating counterclockwise movements in the output-inflation-plane. This is illustrated in an example in which size and length of the business cycle depend on the responsiveness of effort to changes in the unemployment rate.

1. *Introduction*

The efficiency wage hypothesis has recently been put forth to explain the existence of involuntary unemployment[1]. This hypothesis asserts that workers' efforts and thus productivities depend positively on the real wages paid to them. Firms may then find it profitable to pay wages in excess of the market clearing value because the wage that minimizes firms' labor costs per efficiency unit of labor may be higher than the wage that clears the labor market. Equivalently, a wage cut triggered by excess supply may lower productivity more than proportionately and thus increase labor costs. Therefore firms pay a wage which is consistent with persistent involuntary unemployment.

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[1] See, for example, Akerlof (1982); Bowles (1981, 1983); Calvo (1979); Foster and Wan (1984); Malcomson (1981); Miyazaki (1984); Salop (1979); Schlicht (1978); Shapiro and Stiglitz (1984); Solow (1979); Stoft (1982a, 1982b); Weiss (1980); Weisskopf, Bowles, and Gordon (1983). For a survey of this literature see Yellen (1984).

Although this explains unemployment, it does not account for fluctuations in output and employment as can be observed during business cycles. In particular anticipated changes in aggregate demand due to a change in the nominal stock of money have no real effects because firms change prices and wages in such a way that real wages, relative prices and real balances remain unchanged[2].

To obtain nonneutrality of aggregate demand shocks Akerlof and Yellen (1985) have proposed a model in which sticky price and wage behavior that would cause significant business cycle fluctuations is consistent with near rationality in an economy with efficiency wage setting. A demand shock requires as optimal response an equiproportionate adjustment of nominal wages and prices. However, if a firm fails to behave this way, the consequent loss in profit is only second-order small. Notwithstanding this, the effect on aggregate output and employment of near rational behavior is of first order.

An alternative reason for the nonneutrality of aggregate demand shocks in the context of efficiency wages is suggested in this paper. Its two distinctive features are, first, to assume that effort not only depends on the real wage but also on the unemployment rate, and second, that the firms' production technologies exhibit non-decreasing returns to scale. The latter is compatible with constant marginal cost. This, together with the standard assumptions of monopolistic competition and isoelastic demand curves, implies that firms optimally set their output price as a fixed markup over the nominal wage. This further entails that, if the effort level and hence the efficient real wage were independent of the unemployment rate, then firms would neither change the nominal wage nor their own output price in response to a demand shock. They would react by solely adjusting labor input and production.

When, on the other hand, the effort level is influenced by the unemployment rate, then the change in labor input following a demand shock will induce an adjustment of the efficiency real wage. As a consequence, both nominal wages and prices will be adjusted which will in turn imply a revision of labor input and production decisions.

Our formal modelling of the process just outlined is capable of generating counterclockwise movements in the output-inflation space. Depending on how inflation expectations are formed, these cycles are more or less prolonged. As will be argued, inflation expectations can reasonably be linked to the responsiveness of effort with respect to the unemployment rate. If the link

[2] We shall focus in this paper on shifts in aggregate demand that are due to a change in the nominal stock of money. This is standard in the "New Keynesian Economics" literature and the "reason for choosing to study this rather than the effects of a change in tastes, for example, is that such a change in nominal money would have no real effects in our model under perfectly competitive behavior. Thus whatever effects it has derive from departures from perfectly competitive behavior" (Blanchard and Fischer, 1989, p. 376).

between effort and the unemployment rate is very weak, then there will be a large output and employment effect with sluggish price response. If on the other hand the effort level is very responsive to changes in unemployment then we may obtain a pure price and wage change without any effect on real variables. We illustrate this fact in an example where in dependence of a one-dimensional parameter reflecting the elasticity of effort with respect to the unemployment rate there are outcomes that include the one corresponding to perfectly flexible prices and no output change as well as the one obtained for fixed prices and maximum output change. As we argue in this paper, the most plausible outcome seems to lie in the middle where the model produces full fledged business cycles.

The remainder of the paper is organized as follows. In section 2 we present the model, explore firms' behavior and describe the long-run equilibrium. In section 3 we consider demand shocks in the form of money supply changes. We set up the dynamic model, derive the results described above and present a numerical simulation of a business cycle. Section 4 contains concluding remarks.

2. *The Model*

As in Akerlof and Yellen (1985) and Blanchard and Kiyotaki (1987), there are a fixed number of identical firms acting in a monopolistically competitive output market. Each firm sets its price and wage to maximize profits, under the assumption that changes in its own price will have no effect on the prices charged by rival firms or on the average price level.

Accordingly, let the demand curve facing each firm be

$$Y = (p/\bar{p})^{-\eta}(M/\bar{p}), \ \eta > 1 \tag{1}$$

where Y is output, p the price of the firm's output, $\bar{p}$ the average price level, and M the money supply per firm[3]. In long-run equilibrium all firms charge the

[3] The demand function in (l) can be derived explicitly from households' utility functions in consumption of goods and real money balances of the form

$$U_j = \left(\left(\sum_{i=1}^{n} C_{ij}^{\ (\phi-1)/\phi} \right)^{\phi/(1-\phi)} \right)^{\gamma} (M_j / p)^{1-\gamma}$$

where C_{ij} denotes the consumption of good i by household j and n is the number of goods (= number of firms). M, the "money supply per firm" in (1), is equal to $[\gamma/(1-\gamma)n]\overline{M}$, where $\overline{M}$ is the total sum of money balances in the economy. Since M is linear in $\overline{M}$, an increase in $\overline{M}$ affects M proportionately, and thus there is no loss in generality to work in (l) with M rather than $[\gamma/(1-\gamma)n]\overline{M}$. For more details see Blanchard and Kiyotaki (1987) or Blanchard and Fischer (1989).

The assumption that firms are identical is standard and made for technical convenience only. It is not critical in the sense that all results would qualitatively generalize to the case where firms may have different technologies but of the same type (in this paper, all production functions would be of the form $f_i(e,\ell) = \gamma_i(e\ell - k_i)$, see (3)).

same price $p = \bar{p}$, so that equation (l) becomes

$$Y = M / \bar{p} \tag{2}$$

Labor supply of households per firm is assumed to be fixed and equal to $L > 0$.

Firms' Behavior

Firms produce output according to the production function

$$Y = \gamma(e\ell - k), \; \gamma > 0, \; k \geq 0 \tag{3}$$

where e is the effort level of workers and ℓ the number of workers hired. γe is the marginal productivity of an extra worker and γk represents a fixed amount of overhead labor which must be employed to produce any output at all. The production function (3) can be viewed as a first-order approximation in the relevant operating range.

Effort e is assumed to depend on the real wage paid ω, and on the unemployment rate u, i.e. $e = e(\omega,u)$, with $e_\omega > 0$, $e_u > 0$. Moreover we assume that for any $u \in (0, 1)$ there is a unique $\omega^*(u)$ so that

$$e_\omega(\omega^*(u),u) = \frac{e(\omega^*(u),u)}{\omega^*(u)} \tag{4}$$

and

$$e_\omega(\omega,u) > \frac{e(\omega,u)}{\omega} \Leftrightarrow \omega < \omega^*(u)$$

This means that, for any given unemployment rate, the elasticity of e with respect to ω is less than one for $\omega > \omega^*(u)$ and is greater than one for $\omega < \omega^*(u)$. An example of such a function is

$$e(\omega,u) = \max\left\{0, -a + b\left(\frac{u}{1-u}\right)^{\beta}\omega^{\alpha}\right\}, \; 0 \leq \beta, \; 0 < \alpha < 1, \; a, b > 0 \tag{5}$$

For given signals M, $\bar{p}$ and u a firm's problem is

$$\max_{p,w,\ell} \; p\gamma(e(w/\bar{p},u)\ell - k) - w\ell$$

$$\text{s.t.}\; \gamma(e(w/\bar{p},u)\ell - k) \leq (p/\bar{p})^{-\eta}(M/\bar{p})$$

It is easy to calculate that the optimal nominal wage is

(6) $$w = \omega^*(u)\bar{p}$$

This means that the firm chooses w so that the elasticity of effort with respect to the real wage is unity. This is a standard result in efficiency wage models and represents the condition that the firm strives to operate at that real wage at which unit cost of a labor efficiency unit is minimized.

In the following we denote with e the effort level given by $e(\omega^*(u), u)$. It depends in general on u but it is a convenient simplification of our analysis to assume functional forms of e (•) so that e is independent of u[4]. This holds for example for the function given by (5) in which case one obtains $e = a\alpha/(1-\alpha)$[5].

To proceed in the solution to the firm's profit maximization problem we solve (1) and (3) for p and ℓ, respectively:

(7a) $$p(Y) = \bar{p}(M/\bar{p})^{1/\eta}\, Y^{-1/\eta}$$

(7b) $$\ell(Y) = (Y + \gamma\; k)/\gamma e$$

This leads to the marginal revenue

$$MR(Y) = \frac{\eta - 1}{\eta}\, p(Y)$$

and the marginal cost function

$$MC(Y) = w/\gamma e$$

From this we obtain the optimal price

$$p = \frac{\eta}{(\eta - 1)\gamma e}\, w$$

[4] Of course this does not mean that e_u is zero.

[5] For the effort function in (5), $e(\omega,u)$ is zero if u=0, due to the max{0,•}-operator. For u>0 that operator is never effective, however, since $\omega^*(u)$ is always such that $e(\omega^*(u),u) = \alpha a/(1-\alpha)$, and thus positive.

Thus the firm sets its price as a mark up over the nominal wage w. Using (6) we can rewrite this as

$$p = \frac{\eta \omega^*(u)}{(\eta - 1)\gamma e}\,\overline{p} \tag{8}$$

From this it is clear that the firm's price is independent of M, i.e. changes in demand due to changes in M do not induce a firm to change its price[6]. As long as a firm does not perceive a change in the signals $\overline{p}$ and u its only reaction to a demand shock is a change in employment of labor and production.

Long-run Equilibrium

In a long-run equilibrium the signals $\overline{p}$ and u that each firm receives must be reproduced by firms' optimal responses to these signals. From (8) it is immediate that this requires

$$\omega^*(u) = \frac{\eta - 1}{\eta}\gamma e \tag{9}$$

A solution u* to (9) is the economy's long-run unemployment rate. Given the inelastic labor supply per firm L, this further implies for the long-run employment level ℓ^*

$$\ell^* = (1 - u^*)L \tag{10}$$

From (2) and (7b) this yields

$$\frac{(M/\overline{p}) + \gamma k}{\gamma e} = (1 - u^*)L$$

or

$$\overline{p}^* = \frac{M}{\gamma[e(1 - u^*)L - k]} \tag{11}$$

for the long-run price level in the economy, given M. Evidently $\overline{p}^*$ is proportionate to M. Thus the long-run effect of a change in M on employment

[6] This is generally true for the case of an isoelastic demand curve and marginal cost independent of output.

and production is nil whereas the percentage change in the price level is equal to that in M. In the short run however, employment and production may be affected as we aim to show in the next section. Before we proceed to this point we want to assure the existence of a long-run equilibrium $(\bar{p}^*, u^*) \in R_+ \times [0,1]$ for any given M>0.

To this end it is sufficient to assume that $e_\omega(\omega,u)$ be continuous in $u \in (0,1)$ and

$$\left.\begin{array}{l} e_\omega(\omega,u) \rightarrow 0 \text{ for } u \rightarrow 0 \\ e_\omega(\omega,u) \rightarrow \infty \text{ for } u \rightarrow 1 \end{array}\right\} \text{ for all } \omega > 0$$

which is fulfilled for example by the function in (5) if $\beta > 0$. Then there exists u* such that

$$e_\omega\left(\frac{\eta-1}{\eta}\gamma\ e,\ u^*\right) = \frac{\eta}{(\eta-1)\gamma} = \frac{e}{\frac{\eta-1}{\eta}\gamma\ e}$$

and hence $\frac{\eta-1}{\eta}\gamma\ e = \omega^*(u^*)$, that is (9) is met.

Regarding the existence of $\bar{p}^*$, from (11) we merely have to assume $k < e\,(1-u^*)L$ which causes no problem since even the extreme case k=0 is compatible with our framework.

3. *Demand Shocks*

We assume that the economy is originally in a long-run equilibrium $(M_0, \bar{p}_0, u^*)$. Then the money supply changes to $M := M_0(1+\varepsilon)$. How does the economy react? From (11) it is clear that the new long-run equilibrium price level has to be

$$\bar{p}_\infty := \bar{p}_0(1+\varepsilon)$$

but the economy may not reach this price level instantaneously. The reason is that a change in M *ceteris paribus* does not induce a firm to change its nominal wage or its output price. Both these variables depend on the perceived average price level $\bar{p}$ and on the unemployment rate u only, from (6) and (8). But $\bar{p}$ will not change unless firms have reason to change their own prices, and u can change only if firms change their output and employment decisions. Thus an effect on real variables is bound to occur to change firms' wages and prices.

Since by (l) and (7b)

$$\ell = \frac{(p/\overline{p})^{-\eta}(M/\overline{p}) + \gamma k}{\gamma e} \tag{12}$$

a firm does adjust its employment level in reaction to a money supply shock and so it will also modify its wage and price decision. But the latter can be expected to occur with some delay, only after the change in ℓ by sufficiently many firms has had its impact on the economy-wide unemployment rate u and firms are convinced that the change in u has been perceived by workers[7]. This differs of course from what the rational expectations equilibrium paradigm would predict, namely that the economy jump immediately to its new long-run equilibrium. Beyond the reasoning given above we will lend further support to our view in the discussion to come.

For the formal treatment of the adjustment process just described we divide time in periods t = 0,1,2... . In period 0 the economy is in its old long-run equilibrium. Then money supply is changed to $M = M_0(1+\varepsilon)$. At the beginning of each of the subsequent periods, firms set their wages w_t and prices p_t. In doing so, they seek to anticipate the ensueing behavior of households regarding their consumption and effort decisions. Period-t consumption decisions are reflected by the demand curve and depend on, other than the firm-specific price p_t, the average price $\overline{p}_t$ and money M_t, see (1). Whereas M_t=M is known, $\overline{p}_t$ is uncertain, and therefore we assume firms to form expectations $\overline{p}_t^e$.

Regarding the effort decision by households in period t, it depends on their perceptions of the real wage and the unemployment rate. Whereas it is relatively easy for households to note increases in the price level, simply because they are buying goods all the time, they are less autonomous in perceiving the unemployment rate. This is because the unemployment rate is a macroeconomic variable which cannot be observed on an individual level but for which data have to be collected by a central authority like the bureau of labor statistics, and which is published at discrete points of time only, say once a month. Therefore we think it reasonable to assume that workers always base their effort decision on the last unemployment rate figure available which is in period t u_{t-1}. Under this assumption firms expect effort in period t to be $e(w_t/\overline{p}_t^e, u_{t-1})$, and thus the parameter values relevant to firms' period-t decision in w_t and p_t are M, $\overline{p}_t^e$ and u_{t-1}.

Since all firms are identical, the true average price will be $\overline{p}_t = p_t$. Thus period-t output is $Y_t = M/p_t$, being produced by use of labor $\ell_t = ((M/p_t)+\gamma k)/\gamma e$. This gives rise to a period-t unemployment rate $u_t = 1-\ell_t/L$. Once the new

[7] We neglect here the possibility of entry and exit of firms since it would not nullify the nonneutrality of money due to the factors considered in this paper. Therefore, and also because we want to isolate the possible effect of money changes on prices and output via unemployment rate and effort, we abstract from that aspect.

unemployment rate is out, firms revise their wage and price decisions to w_{t+1} and p_{t+1} using also revised expectations $\overline{p}^e_{t+1}$, and the process just described is repeated.

Algebraically we can summarize the dynamics of the economy by means of the following equations:

$$w_t = \omega^*(u_{t-1})\overline{p}^e_t$$

$$p_t = \frac{\eta}{(\eta-1)\gamma e} w_t$$

$$u_t = 1 - \frac{M/p_t + \gamma\ k}{\gamma e L}$$

Writing

$$\overline{p}^e_t = (1+\pi^e_t)\overline{p}_{t-1}$$

where π^e_t is the expected inflation rate for period t, we can express the above set of equations in the reduced form[8]

$$p_t = \frac{\eta}{(\eta-1)\gamma e}\omega^*(u_{t-1})(1+\pi^e_t)p_{t-1} \tag{13}$$

$$u_t = 1 - \frac{M/p_t + \gamma\ k}{\gamma e L} \tag{14}$$

The question at this point is what is the value of π^e_t, $t \geq 1$, and how is it determined. Assuming that firms have learned ε and believe that the shock is once-and-for-all, it is clear that $0 \leq \pi^e_1 \leq \varepsilon$. If $\pi^e_1 = 0$, then $p_1 = \overline{p}_0$ and the realized first period inflation rate is zero as well, thus confirming expectations. In that case, the unemployment rate becomes

$$u_1 = 1 - \frac{M/\overline{p}_0 + \gamma\ k}{\gamma\ e} < u^*$$

If effort were independent of u, this would be the end of the story: both w and p depend on u only through its impact on the efficiency wage ω* (u) which in turn varies with u only if effort varies with u. Firms would simply increase employment and output, with no change in prices. This is due to isoelastic demand and constant marginal cost, a well-known but somewhat special

[8] The behavior of the dynamic system would not qualitatively change if in (13) instead of u_{t-1}, we used $u^e_t = u((1+\pi^e_t)p_{t-1})$, where $u(p) = 1-((M/p)+\gamma k)/\gamma e L$, as long as the function $p \to \omega^*(u(p))$ is less than unit-elastic. To the interested reader the proof is supplied by the author upon request.

scenario, in which no menu cost are needed to get real effects of nominal money[9].

If $\pi_1^e = 0$ and effort is responsive to the size of unemployment, then the period-one-change in u will imply a period-two-change in w and p. Hence firms have reason to expect a positive inflation rate from period two on. This ignites a process along which quantities as well as prices change.

The above reasoning suggests a positive correlation between the responsiveness of effort to changes in unemployment and expected inflation rates - an issue that we will further pursue in a later example.

In the other extreme case that $\pi_1^e = \varepsilon$, the economy would jump within one period to its new long-run equilibrium and, if $\pi_t^e = 0$ for all $t \geq 2$, remain there. This seems not a very likely event, however, since it is optimal for any firm to set $p_1 = \bar{p}_\infty$ if and only if it can be sure that all other firms will go to $\bar{p}_\infty$ as well. Indeed, from the profit function

$$\pi(p, \bar{p}) = (p / \bar{p})^{1-\eta} M - w * \bar{p} \frac{p^{-\eta} \bar{p}^{(\eta-1)} M - \gamma \ k}{\gamma \ e}$$

one calculates

$$\frac{\partial \pi}{\partial p}(p, \bar{p}) = (p / \bar{p})^{-\eta} M \left(\frac{\eta \omega *}{\gamma e} \cdot \frac{1}{p} - (\eta - 1) \frac{1}{\bar{p}} \right)$$

Starting from a long-run equilibrium situation, $\eta\omega * / \gamma e = \eta - 1$ and therefore

$$\frac{\partial \pi}{\partial p}(p_1, \bar{p}) \begin{cases} = 0 \Leftrightarrow p_1 = \bar{p} \\ < 0 \Leftrightarrow p_1 > \bar{p} \end{cases}$$

Thus, if $\bar{p}_1 < \bar{p}_\infty$., it is suboptimal for a firm to set $p_1 = \bar{p}_\infty$. If a firm has the slightest doubt that all other firms go to $p_1 = \bar{p}_\infty$ then it is better for the firm to choose a price p_1 below $\bar{p}_\infty$.

This reasoning suggests that firms may be reluctant to go instantaneously all the way to the new long-run equilibrium price $\bar{p}_\infty$. If some fraction of firms in fact refuses to do so, these firms are likely to be better off than those firms which did go to $\bar{p}_\infty$

Knowing this, firms suspect each other of being sluggish in their price response to the shock and therefore it is in turn optimal for them to increase their own price by only a fraction of the money disturbance ε. But this will

[9] The case that effort is independent of u is somewhat artificial in our context since, due to (9), it is in general incompatible with long-run equilibrium. However, it can be regarded the limiting case of effort reacting very weakly to changes in u. For example, for the functional form (5) equilibrium exists for any β>0, although not necessarily for β=0. But effort is continuous in β, and thus a pure employment and output reaction by firms (β=0) can be approximated arbitrarily close.

produce precisely the effect they worried about and thus confirm them in their view of other firms' behavior. Firms will choose to wait and see whether other firms increase their prices substantially enough before they revise their expectations of inflation[10]. Compatible with this behaviour of firms is the following hypothesis:

$$\text{(15)} \qquad \begin{aligned} &\pi_1^e = c_0\varepsilon, \; 0 \le c_0 \le 1 \\ &\pi_t^e = c_1\pi_{t-1} + c_2\pi_{t-2}, \;\; c_1, c_2 \ge 0, \;\; t \ge 2 \end{aligned}$$

where $\pi_t = \overline{p}_t / \overline{p}_{t-1} - 1, \;\; t \ge 1,$ and $\pi_0 = 0.$

The system of equations (13), (14) and (15) can produce, for appropriate values of c_1 and c_2, counterclockwise movements in output-inflation-plane as is typically observed in real economies[11]. This is studied in more detail in the following example.

Example of a Business Cycle

The effort function is assumed to be given by (5). Then, from (4),

$$\text{(16)} \qquad \omega^*(u) = \left[\frac{a}{(1-\alpha)b}\left(\frac{1-u}{u}\right)^{\beta}\right]^{1/\alpha}$$

and $e = e(\omega^*(u), u) = \alpha a/(1-\alpha)$[12]. Equ. (9) and (16) yield for the long-run unemployment rate u*

$$\frac{\eta-1}{\eta}\gamma e = \left[\frac{a}{(1-\alpha)b}\left(\frac{1-u^*}{u^*}\right)^{\beta}\right]^{1/\alpha}$$

Setting $\alpha = 0.5$, $a = 1$, $\gamma = 2$ and $\eta = 2$, one obtains e=1 and

$$\text{(17)} \qquad b = 2\left(\frac{1-u^*}{u^*}\right)^{\beta}$$

[10] This state of affairs can be formally represented as conjectural equilibrium in the sense of Rubinstein and Wolinsky (1990, Def. 4, p. 5). Using their terminology, the signals s_i given to firms could be defined as elements of $S_i = \{-1,0,1\}$, indicating whether $\overline{p}_t < \overline{p}_\infty, \overline{p}_t = \overline{p}_\infty$ or $\overline{p}_t > \overline{p}_\infty$, respectively. For example, if $s_i = -1$, firms expect that the average price will be smaller than $\overline{p}_\infty$. They will then optimally respond by setting p_t at a value below $\overline{p}_\infty$. But then the true average price will also be smaller than $\overline{p}_\infty$, thus confirming the signal s_i.

[11] See for example Hall and Taylor (1986), chapter 15.

[12] Equ. (16) implies a negative monotone correlation between real wage and unemployment. Data suggest that this relation be weak. This is not incompatible with our model since (4) yields $d\omega/du = (e_u - \omega e_{\omega u})/\omega e_{\omega\omega}$ which, in general, can take any sign, including zero, since e_u is positive and $e_{\omega u}$ may be positive as well. In our specific example the elasticity of ω to u is $(d\omega/du)/(\omega/u) = -[\alpha(1-u)]^{-1}\beta$. For example, for $\alpha=0.5$ and $u=0.1$, this expression varies from -0.01 for $\beta=0.005$ to -0.15 for $\beta=0.07$, the smallest and highest values of β chosen in our subsequent simulations. Thus the unemployment-real wage correlation appears quite flat, indeed.

Assuming that the long-run unemployment rate is a data known by the actors in the economy, it appears natural that workers evaluate the actual unemployment rate with respect to u*. Using (17), this can be taken into account by further specifying the effort function to be

$$e(\omega, u) = \max\left\{0, -1 + 2\left(\frac{1-u^*}{u^*} \bullet \frac{u}{1-u}\right)^{\beta} \omega^{\alpha}\right\}$$

$$= \max\left\{0, -1 + 2\left(\frac{u/u^*}{(1-u)/(1-u^*)}\right)^{\beta} \omega^{\alpha}\right\}$$

Then $\omega^*(u) = [u^*/(1-u^*) \bullet (1-u)/u]^{2\beta}$ and (13) becomes

$$p_t = \left(\frac{u^*}{1-u^*} \bullet \frac{1-u_{t-1}}{u_{t-1}}\right)^{2\beta} (1+\pi_t^e) p_{t-1} \tag{18}$$

With respect to (14) we choose k=40 and L=100 so that it yields

$$u_t = 1 - \frac{M/p_t + 80}{200} \tag{19}$$

Regarding the formation of expected inflation rates, we assume that the coefficients c_0, c_1 and c_2 in (15) depend on the value of β. The smaller is β, the less elastic is effort with respect to changes in the unemployment rate u. For β=0 effort is independent of u and in that case a change in the money supply affects neither w nor p. Therefore inflation will be zero and hence agents have no reason to expect an inflation rate other than zero. This means that in the case β=0 we could expect c_0 to be zero, too. For higher values of β, workers are more and more responsive to changes in u and therefore firms' consequent price changes more marked. Since firms know this, they have reason to expect a greater change in inflation the greater is β. A simple way to express this is

$$c_0 = \begin{cases} k_0 \text{ if } \beta \leq 1/k_0 \\ 1 \text{ if } \beta > 1/k_0 \end{cases} \tag{20}$$

where k_0 is some positive constant.

Regarding the coefficients c_1 and c_2 it seems reasonable to assume that they are inversely related to c_0. A big c_0 means that firms adjust their average price expectations mainly and quickly in response to the change in demand, before they can actually observe other firms' behavior. Evidently then firms do not give much importance to observations regarding rival firms' price setting response. But this is equivalent to saying that the coefficients c_1 and c_2 are relatively small.

This reasoning is taken into account when postulating

$$\text{(21)} \qquad \begin{aligned} c_1 &= (1-c_0)k_1 \\ c_2 &= (1-c_0)k_2 \end{aligned}$$

where k_1 and k_2 are positive constants.

Combining (15) with (20) and (21) leads to

$$\text{(22)} \qquad \begin{aligned} \pi_1^e &= \min\{1, k_0\beta\}\varepsilon \\ \pi_t^e &= (1-\min\{1, k_0\beta\})(k_1\pi_{t-1} + k_2\pi_{t-2}), \quad t \geq 2 \end{aligned}$$

The system of difference equations (18), (19) and (22) allows to numerically simulate the dynamical behavior of the economy following a demand shock. If, for given $k_0 > 0$, β is such that $c_0=1$, then firms anticipate the price level to jump instantaneously to its new long-run equilibrium level and to remain there.

If in the opposite extreme case $\beta=0$, then no price change will take place but output and employment will increase and stay at its higher level forever. The more realistic cases are presumably the intermediate ones, i.e. for β such that $0 < \beta < 1/k_0$. For example for $k_0=10$, $k_1=0.4$, $k_2=0.2$, $u^*=0.1$, $M_0=100$ and $\varepsilon=0.1$ Figures 1 to 4 display business cycle motions for various values of β. The counterclockwise type of movement is consistent with actual data in many economies.

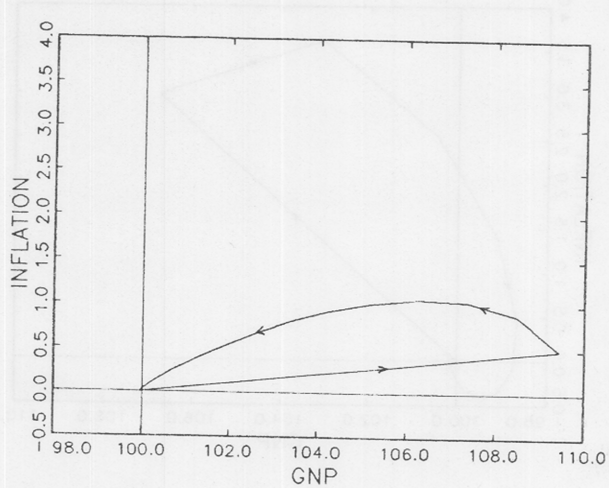

Figure 1: $\beta = 0.005$

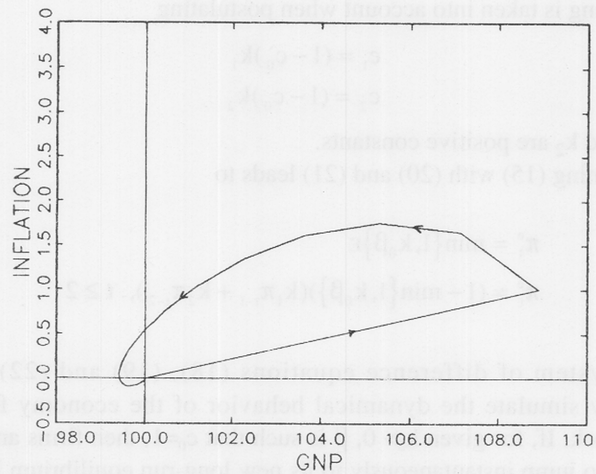

Figure 2: $\beta = 0.01$

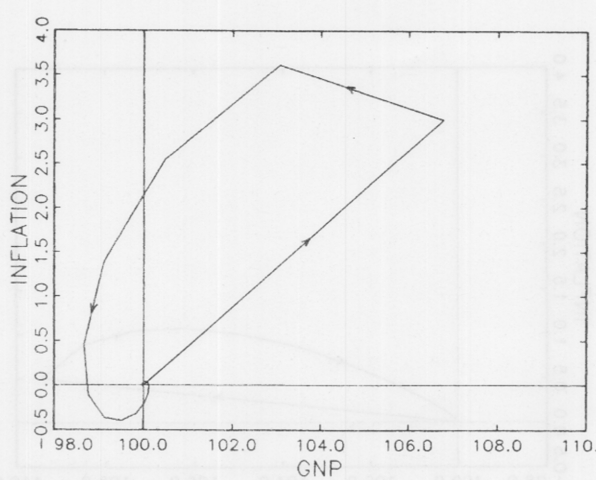

Figure 3: $\beta = 0.03$

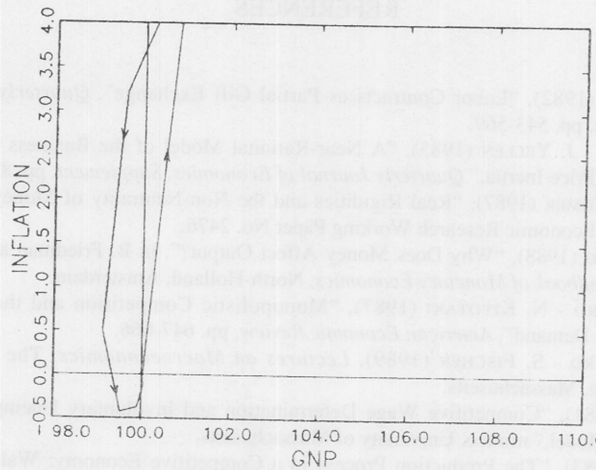

Figure 4: $\beta = 0.07$

4. *Concluding Remarks*

In this paper we have presented a simple business cycle model based on the efficiency wage hypothesis. Consistent with actual data the model can generate counterclockwise movements in the output-inflation plane. Extending other models displaying this kind of dynamics[11], the price and wage setting behaviour is modelled here explicitly.

The model illustrates the importance of expectations for the dynamic behaviour of the economy. Expectations in turn are linked to the responsiveness of effort to the unemployment rate. Depending on the tightness of this link, a whole range of different dynamics can be generated, reaching from the case of perfectly flexible prices with no real effects to the opposite extreme case of fixed prices and pure quantity effects. This has been illustrated in an example which predicts that the real effects of monetary shocks are greater when unemployment has small effects on effort. This is consistent with and extends earlier works [Ball and Romer (1987), Blanchard (1988)] that predict that greater real wage rigidity - that is less responsiveness of the real wage to unemployment - increases the effects of money. Indeed, unemployment has small effects on efficiency wages when it has small effects on effort.

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