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STAGFLATIONARY CONSEQUENCES OF PRUDENT MONETARY POLICY IN A UNIONIZED ECONOMY

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Stylised models of the policy game between monetary policy makers and the private sector have suggested that discretionary policy regimes suffer from an inherent inflationary bias and that pre-commitment to a target rate of inflation may be desirable. This paper shows that in the presence of labour unions, the monetary policy game can lead to radically different results: a central bank that is completely indifferent to the level of inflation may obtain outcomes with high employment rates and zero inflation while 'prudent', inflation-averse, central banks generate stagflation with positive inflation and low rates of employment.

1. Introduction

IT IS OFTEN argued that systematic demand policy has no effects on employment and real output, and that attempts to boost demand merely lead to inflation. Moreover, it is suggested that the sequential structure of the 'policy game' causes problems of time inconsistency and that discretionary policy regimes suffer from an inherent inflationary bias. The same line of reasoning suggests that if the objective functions of different governments are known, inflation-averse governments will achieve low inflation rates at no cost in terms of increased unemployment. In other words, government pre-commitment to a target rate of inflation is desirable in these models, and the analysis lends support to proposals for the constitutional independence of central banks.¹

Extended versions of the analysis allow for repetitions of the policy game and introduce reputational complications, and it is well-known that the results of these extended versions of the model are sensitive to the precise specifications. But as shown by Cubitt (1992), the results of the one-shot game may also be quite fragile. Cubitt introduces a monopoly union and assumes that the union cares about both inflation and the level of output.² Comparing three different structures of the policy game, the Nash equilibrium under simultaneous play and the two Stackelberg equilibria with either the union or the government as the leader, he then shows that the monetary authorities may

¹ The initial analysis of the dynamic inconsistency of optimal policies was due to Kydland and Prescott (1977); later work includes Barro and Gordon (1983), Rogoff (1985a), Backus and Driffill (1985), Persson and Tabellini (1990), and Lockwood and Philippopoulos (1994).

² It is a standard assumption in the literature on corporatism that unions take into account the inflationary effects of their wage demands (e.g. Calmfors and Driffill, 1988).

benefit from being in the position of a Stackelberg follower. In other words, policy pre-commitment can be harmful.³

This paper, like Cubitt's, considers a unionized economy and assumes that unions are interested in both output and inflation. But the focus is slightly different and the paper extends Cubitt's analysis in several directions. Throughout the paper, first, it is assumed that wage-setting unions act as Stackelberg leaders *vis-à-vis* the monetary authorities.⁴ The motivation for this assumption is empirical. Labour market structures and wage contracts generate wage stickiness within the contract period. Monetary policy on the other hand must retain a large amount of short-term flexibility in order to cope with shocks from other (non-labour market) sources. This need for short-term flexibility makes the pre-commitment of the monetary authorities to particular values of the monetary instruments both difficult and undesirable, and credible government 'pre-commitment' has to be achieved in a different way. A possible solution is the constitutional independence of the central bank. Unions may be Stackelberg leaders *vis-à-vis* the central bank, but independence makes possible the separation of the objectives of the central bank from the true social preferences. Thus, there are effectively three players: (i) a central bank maximizing its objective function; (ii) wage setting unions which take as given the central bank's objective function and anticipate the reaction of the central bank; and (iii) a government (or constitution) which sets the parameters of the central bank's objective function. This paper considers the optimal specification of these central-bank objectives. A traditional Barro–Gordon–Rogoff argument implies that the central bank should focus strongly on price stability. It turns out, however, that with a single, inflation-averse monopoly union this conclusion is reversed: it becomes optimal for the central bank to pursue the output target defined by the social welfare function, disregarding completely the inflationary consequences. In the absence of stochastic shocks this specification of the objective function makes it possible to achieve both price stability and the output target.

The case with a single monopoly union is extreme and, as a second extension of Cubitt's analysis, the paper allows for a decentralized union structure. This extension weakens the conclusions slightly. It is still optimal for the central bank to neglect inflation in the pursuit of an output target, but the output target should not in general be equal to the government's true target: to avoid excessive inflation, the central bank's target may be lower than the government's preferred output level.

The third important change, compared to Cubitt's analysis, is the introduction of hysteresis effects. This change strengthens the case against policy pre-commitment to low inflation since the model implies that all central banks

³ Drawing on Cubitt (1992), Jensen (1997) qualifies Rogoff's (1985b) analysis of policy cooperation in the two-country case by showing that cooperation can be beneficial.

⁴ The results clearly depend on this assumption. See Cubitt (1995) for an analysis of the case in which the central bank has the first move.

will achieve price stability in the long run, even if unions are decentralized, but 'soft' banks (which do not focus exclusively on inflation) also reach their output target.

The paper is in four sections. Section 2 sets out a one-shot model which includes inflation-indifferent unions and a central monopoly union as special cases. Section 3 considers a dynamic game with endogenous changes in union membership, and a final section comments briefly on some of the main conclusions.

2. A one-shot game

Consider an economy with n unions ($n \geq 1$) and let the preferences of the i 'th union be described by the pay-off function

$$V_i(\pi_t, y_{it}) = -a\pi_t^2 - b(y_{it} - y_i^*)^2 = -a\pi_t^2 - b(y_{it} - y^*)^2 \quad (1)$$

where π is inflation, y_i is (the logarithm of) the level of employment of the union's members and $y_i^* = y^*$ the desired employment level. Each union sets the growth rate ω_i of its money wages so as to maximize (1) taking into account the (conjectured) effects of ω_i on inflation, π , and employment, y_i . These effects depend on the links between ω_i and the average rate of wage inflation ω , and between relative wages and the share of the union in total employment. Assuming symmetry across unions, the following specification is used

$$\partial\omega_t/\partial\omega_{it} = \delta \quad (2)$$

$$y_{it} - y_t = y_{it-1} - y_{t-1} - \varepsilon(\omega_{it} - \omega_t) \quad (3)$$

$$y_t = y_{t-1} + \lambda(\pi_t - \omega_t) \quad (4)$$

where $y = 1/n \sum_{j=1}^n y_j$, $\omega = 1/n \sum_{j=1}^n \omega_j$. Equation (2), which captures the influence of union i on average wage inflation, includes a simple Nash specification as a special case.⁵ Equations (3)–(4) express firms' employment decision. Equation (3) says that the change in the share of union i in total employment is inversely related to the change in its relative wage. Complete decentralization with atomistic unions appears as a special case with $\delta = 0$ while, at the other extreme, a single monopoly union implies $\delta = 1$ and $y_i = y$. Turning to eq. (4), price inflation in excess of (average) wage inflation implies a reduction in real wages and hence an increase in output and employment (see the Appendix for a more detailed justification of eqs (3)–(4)).

⁵ By definition the average rate of growth of wages is given by

$$\omega = \sum_{i=1}^n \left(w_i L_i / \sum_{j=1}^n w_j L_j \right) \omega_i = 1/n \sum_{i=1}^n \omega_i$$

where the last equality makes use of the symmetry assumption. Hence, assuming $\partial\omega_j/\partial\omega_i = 0$ for $j \neq i$, $\partial\omega/\partial\omega_i = w_i L_i / \sum_{j=1}^n w_j L_j = 1/n$.

The objectives of the central bank are represented by the pay-off function

$$V_b(y_t, \pi_t) = -\alpha\pi_t^2 - \beta(y^{**} - y_t)^2 \quad (5)$$

where y^{**} is the central bank's desired average level of employment. It is assumed that $y_i^* = y^* < y^{**} \leq y^{\max}$, where $y^{\max}$ corresponds to full employment in the absence of insider-related distortions in the labour market.

For any given rate of wage inflation ω_t , the central bank sets nominal demand so as to maximize (5) subject to the constraint (4). The solution to this decision problem is given by

$$\pi_t = \beta\lambda(y^{**} + \lambda\omega_t - y_{t-1})/(\alpha + \beta\lambda^2) \quad (6)$$

$$y_t = y_{t-1} + \beta\lambda^2/(\alpha + \beta\lambda^2)(y^{**} - y_{t-1}) - \alpha\lambda/(\alpha + \beta\lambda^2)\omega_t \quad (7)$$

Equations (6)–(7) imply that

$$y_t + \alpha/(\beta\lambda)\pi_t = y^{**} \quad (8)$$

Anticipating the reactions of the central bank, unions maximize (1) subject to (2)–(4) and (6)–(7). This maximization yields

$$\pi_t = (y_{it} - y^*)[\delta\lambda b\alpha + \varepsilon b(1 - \delta)(\alpha + \beta\lambda^2)]/[\delta a\beta\lambda^2] \quad (9)$$

and aggregating (9) across unions we get

$$\pi_t = C(y_t - y^*) \quad (10)$$

where $C = [\delta\lambda b\alpha + \varepsilon b(1 - \delta)(\alpha + \beta\lambda^2)]/[\delta a\beta\lambda^2]$. The value of C depends on the structure of unions, greater decentralization tending to increase C : for a central union one would have $\delta = 1$ and $C = b\alpha/(a\beta\lambda)$; the atomistic case with $\delta \rightarrow 0$ implies $C \rightarrow \infty$.

Using (10) and (8) we get

$$y_t = Ay^{**} + (1 - A)y^* \quad (11)$$

$$\pi_t = B(y^{**} - y^*) \quad (12)$$

where

$$A = \delta a\lambda^3\beta^2/[\delta a\lambda^3\beta^2 + \delta b\alpha^2\lambda + \varepsilon b\alpha(1 - \delta)(\alpha + \beta\lambda^2)]$$

and $B = \lambda\beta/\alpha(1 - A)$.⁶

For the general case with a, b, α, β all positive, we have $0 < A < 1$ and $0 < B$, and eqs (11)–(12) give a solution with $\pi > 0$ and $y^* < y < y^{**}$. There are several interesting special cases:

- (i) if $\alpha \rightarrow 0$ then $\pi \rightarrow (y^{**} - y^*)\varepsilon(b/a)(1 - \delta)/\delta$ and $y \rightarrow y^{**}$;
- (ii) if $\beta \rightarrow 0$ then $\pi \rightarrow 0$ and $y \rightarrow y^*$;

⁶ Equations (11)–(12) imply that y_t and π_t are independent of the initial position y_{t-1} . Wage inflation is the accommodating variable that makes this possible. Using (4) and (11)–(12), ω_t is given by

$$\omega_t = \pi_t - (1/\lambda)(y_t - y_{t-1}) = (B - A/\lambda)(y^{**} - y^*) + 1/\lambda(y_{t-1} - y^*).$$

- (iii) if $a \rightarrow 0$ then $\pi \rightarrow (y^{**} - y^*)\lambda\beta/\alpha$ and $y \rightarrow y^*$;
- (iv) if $b \rightarrow 0$ then $\pi \rightarrow 0$ and $y \rightarrow y^{**}$;
- (v) if $\delta \rightarrow 0$ then $\pi \rightarrow (y^{**} - y^*)\lambda\beta/\alpha$ and $y \rightarrow y^*$.

Cases (iii) and (v), in which unions pay no attention to inflation or each union has a negligible influence on average inflation, reproduce the standard result from the Barro–Gordon model: employment is always at the ‘natural rate’ y^* and central bank attempts to raise output ($\beta > 0$) lead to inflation. These policy conclusions, however, no longer apply if we assume that unions are non-atomistic ($\delta > 0$) and care about inflation ($a > 0$). To see this, note first that with a single monopoly union we have $\delta = 1$ and the result in case (i) simplifies to $\pi \rightarrow 0$ and $y \rightarrow y^{**}$. Thus, if the monopoly union cares about inflation, an inflation-indifferent central bank ($\alpha = 0$) produces a first-best outcome with zero inflation and output at the optimal level, $y = y^{**}$. Putting it differently: if there is a single monopoly union, it is optimal to choose a constitutional set-up in which an independent central bank is charged with the single task of ensuring the target level of output, paying absolutely no attention to the rate of inflation. Or equivalently the central bank should pre-commit to the desired level of real output y^{**} .⁷ Pre-commitment to a particular level of inflation, on the other hand, will lead to sub-optimal outcomes: with a credible inflation-pre-commitment it will always be optimal for the union to choose $y = y^*$. Consequently $(y, \pi) = (y^*, 0)$ is the best that can be achieved in this way (case (ii)). Turning to intermediate policy regimes ($\alpha > 0, \beta > 0$), it should be noted that unlike an inflation-indifferent central bank, prudent central banks with a dislike for inflation produce stagflationary outcomes with $\pi > 0$ and $y < y^{**}$.⁸

These results may seem paradoxical but the intuition is straightforward. If the central bank is inflation averse (or pre-committed to a particular rate of inflation or growth of nominal demand), the union can take advantage of this aversion (pre-commitment): high money-wage increases will buy lower output (and higher real wages). Whether and to what extent the union will want to exploit this possibility depends on the terms on which it can purchase output changes (that is, the central bank parameters α/β) as well as on its own relative preferences for inflation and output (the parameters a/b). At one extreme we have the inflation-indifferent central bank ($\alpha = 0$) which makes it infinitely expensive for the union to reduce output below y^{**} (case (i)); at the other extreme, the output-indifferent central bank implies that it is costless for the union to reduce output, and the union reaches its bliss-point y^* . In between these two extremes are outcomes with $\pi > 0$ and $y^{**} > y > y^*$.

⁷ The extreme cases $\alpha = 0$ and $\beta = 0$ effectively correspond to a pre-commitment to $y = y^{**}$ and $\pi = 0$, respectively.

⁸ Note in particular that inflation is lowest when either the central bank is inflation-indifferent or the central bank cares only about inflation. These conclusions are the mirror-image of Cubitt's (1995) results that when the central bank moves first, inflation is lowest when either the union is inflation-indifferent or the union cares only about inflation.

Turning now to the case with a decentralized union structure, the policy implications may appear to be less clear-cut. As indicated by case (i) above, decentralization affects the desirability of output pre-commitment: an inflation-indifferent central bank still secures output at the level, $y = y^{**}$, but with decentralized unions there is now a cost in terms of inflation. Decentralization implies that even with an inflation-indifferent central bank, an individual union can affect the relative wage structure and thereby the employment and real wage of its own members; inflation in the $\alpha = 0$ case is the result of this inter-union game over relative wages.

Despite this difference compared with the monopoly-union case, it will be optimal to have an inflation-indifferent central bank. To see this, let the true welfare function be

$$V = V(y, \pi); \partial V / \partial y > 0 \text{ for } y < y^{***} \text{ with } y^* < y^{***}, \partial V / \partial \pi < 0 \text{ for } \pi > 0 \quad (13)$$

and assume that the specification of central-bank objectives is restricted to quadratic pay-off functions as in eq. (5) and that the three parameters y^{**} , α , and β can be chosen freely. The implications of this set-up can be illustrated graphically.

Equation (8), which was derived from the central bank's optimization problem, describes the line GG in Fig. 1. Independently of ω , the central bank always faces the same marginal trade-off between inflation and output: a unit increase in output can be obtained at the cost of an increase of λ in the rate of inflation. Variations in ω and/or in the initial output level y_{t-1} shifts the position of this constraint but leaves the slope unaffected. The GG line represents the points of tangency between the indifference curves and the constraint

FIG. 1

FIG. 2

as ω (and/or y_{t-1}) varies; the line always passes through the central bank's bliss-point at $(y^{**}, 0)$ and has a slope of $-\lambda\beta/\alpha$.

The GG line is a constraint facing unions, and the implications of their constrained optimization is summarized by eq. (10). In Fig. 2 this equation is depicted by the WW line, which passes through the union's bliss-point $(y^*, 0)$ and has a slope C , and the equilibrium solution is found at the intersection of the GG and WW lines.⁹ An increase in α , say, implies that both lines rotate counterclockwise while increased decentralization leaves GG unchanged but increases C and rotates the WW line counterclockwise.¹⁰

Using Fig. 2 it is readily seen that the optimal specification of central bank objectives implies $\alpha = 0$. Thus let $(\bar{y}, \bar{\pi})$ be the outcome associated with $(\bar{\alpha}, \bar{\beta}, \bar{y}^{**})$ where $y^* < \bar{y} < \bar{y}^{**}$ and $0 < \bar{\pi}$. If $\bar{\alpha} > 0$ then this cannot be optimal (with reference to the welfare function V in (13)) since by choosing an alternative objective function with $\alpha = 0, \beta > 0$, and $y^{**} = \bar{y}$ it would be possible to achieve the same output $\bar{y}$ and lower inflation. Graphically, this alternative specification implies a vertical GG curve through $y = \bar{y}$ and a flatter WW curve as indicated in Fig. 3. It follows that given the general welfare function (13) and given the restriction to objective functions of the form (5), the objective function of the central bank should depend exclusively on output, $V^b = -(y - y^{**})^2$ with $y^* \leq y^{**} \leq y^{***}$. The central bank, in other words, should be inflation-indifferent. The basic intuition behind the result is the same as in the case with a monopoly union. If a central bank cares about

⁹ Notice that the GG and WW curves are very different. The GG curve can be defined quite independently of the unions' preferences (and hence independently of the WW curve). The WW curve, on the other hand, is constructed on the basis of a given slope of the GG -curve.

¹⁰ A finite C is ensured as long as a union has any monopoly power (that is, ϵ is finite) and its wage demand has any effect on aggregate inflation (δ is positive).

FIG. 3

inflation, rational unions will try to exploit this inflation aversion in order to reduce employment and increase real wages. It is therefore less costly in terms of inflation if any given level of output is reached through an inflation-indifferent central bank rather than through a central bank with a higher output target and some attention to inflation.¹¹

The analysis has implications for the shape of the long-run Phillips curve. Assume, for instance, that the unions' utility function remains constant but that the policy parameters of the central bank may change. Using (11) and (12) it is readily seen that if only y^{**} varies, then observed values of (y, p) will trace out an old-fashioned Phillips curve with $dy/d\pi = A/B > 0$.¹² Thus, a permanent increase in the output target yields a permanent increase in actual output and employment at the cost of a permanent increase in inflation. This Phillips curve clearly does not hinge on naive expectations, money illusion, or irrational behaviour. Inflation is perfectly foreseen, but with a utility function that depends on both inflation and employment, unions may choose not to

¹¹ If a more flexible form of the objective function is permitted, it may be possible to reach the bliss point ($\pi = 0, y = y^{***}$). One way to do this would be to let y^{**} , the bank's output target, depend positively on the rate of inflation.

If, on the other hand, the objective function is less flexible than assumed, and the output target y^{**} is constrained to be equal to the true output target y^{***} , the optimal value of α may not be zero. Assuming that the 'true social welfare function' takes the same quadratic form as V_b but with parameters α^* and β^* , the outcomes can be evaluated using the expressions in eqs (11)–(12) for $\pi(\alpha, \beta)$ and $y(\alpha, \beta)$. In this case it can be shown that output-indifferent central banks may do better in highly decentralized systems while centralized systems favor inflation-indifferent central banks, the first best solution being obtained in fully-centralized systems with inflation-indifferent central banks.

¹² Equations (11)–(12) imply that $dy = A dy^{**}$ and $d\pi = B dy^{**}$. Hence, variations in y^{**} give rise to the reduced-form relation $dy = A/B d\pi$.

raise money wages in line with prices (inflation may be 'expected' but not 'anticipated' in Rowthorn's (1977) terminology).¹³

3. Hysteresis

So far it has been assumed that the unions' preferred level of output is given exogenously. Arguably, however, y_i^* will change endogenously, actual output and employment producing delayed effects on membership and, following Blanchard and Summers (1987), one may assume that a reduction in employment causes membership in the following period to decline. In so far as unions defend the interests of the current membership this assumption can be captured by

$$y_{it}^* = y_{it-1} \quad (14)$$

The extension of the analysis to include these changes in membership is straightforward if the outcome in each period is determined statically by eqs (11)–(12). Combining eq. (14) with (11) we get

$$y_t^* - (1 - A)y_{t-1}^* = Ay^{**} \quad (15)$$

For $a = 0$ —the standard case with inflation-indifferent unions—we have $A = 0$, and equations (14)–(15) and (11) imply $y_t = y_t^* = y_{t-1} = y_{t-1}^*$ (and $\pi_t = \lambda\beta/\alpha(y^{**} - y_t^*)$). This corresponds to the hysteresis scenario discussed by Blanchard and Summers (but without stochastic shocks). Let us assume, however, that $a > 0$ and consider the implications of different types of central bank. A strong central bank with $\beta = 0$ (that is, an output-indifferent central bank) also implies $A = 0$, and the same hysteresis conclusion applies (but with $\pi = 0$). By contrast, we get $A > 0$ if the central bank is soft and has $\beta > 0$. In this case eqs (15) and (11) imply monotonic convergence of both y^* and y towards y^{**} . Using (12) it then follows that π converges to zero. With endogenous changes in membership, the long-run results thus show a sharp distinction between strong central banks with $\beta = 0$ and all other, soft, central banks that give some weight to output. In the long run both types of central bank achieve zero inflation but unlike the strong type, soft central banks also achieve the output target y^{**} .

It is clearly restrictive to assume that eqs (11)–(12) continue to hold in each period, but this assumption can be relaxed without affecting the qualitative conclusions. Following Lockwood and Philippopoulos (1994), for instance, one might consider linear Markov-perfect equilibria (LMPE) of a dynamic game between unions and the central bank. Thus, assume that the central bank and the unions maximize the intertemporal payoff functions

¹³ With a different source of disturbances other outcomes emerge. Variations in y^* , for instance, produce an observed Phillips curve with the 'wrong' slope ($dy/d\pi = -(1 - A)/B$), and in general the observed long-run Phillips curve can take almost any shape.

$$V^B = \Sigma(1 + \rho)^{-t}(-\alpha\pi_t^2 - \beta(y^{**} - y_t)^2) \quad (16)$$

$$V_i^W = \Sigma(1 + \rho)^{-t}(-a\pi_t^2 - b(y_{it} - y_{it}^*)^2) \quad (17)$$

where r is the discount rate, and assume that $a, b, \alpha, \beta > 0$.

In each period the unions set ω_i and the central bank then decides π . Adopting a Markov assumption, these choices depend on the past history only through the value of the state variables at the beginning of the period. Given the specification of the payoff functions, the payoff-relevant history can be summarized by y^* ,¹⁴ and at an LMPE we have

$$V^B(y_t^*) = (-\alpha\pi_t^2 - \beta(y^{**} - y_t)^2) + (1 + \rho)^{-1} V^B(y_{t+1}^*) \quad (18)$$

$$V_i^W(y_t^*) = (-a\pi_t^2 - b(y_{it} - y_{it}^*)^2) + (1 + \rho)^{-1} V_i^W(y_{t+1}^*) \quad (19)$$

By assumption π_t maximizes the central bank's payoff function given ω_t , while ω_{it} maximizes the i 'th union's payoff function given the union's knowledge of the dependence of π_t and y_{it} on ω_{it} . Hence, using (18)–(19), (2)–(4), and (14) the following first-order conditions must hold

$$-2\alpha\pi_t + 2\beta\lambda(y^{**} - y_t) + (1 + \rho)^{-1}\lambda dV^B(y_{t+1}^*)/dy_{t+1}^* = 0 \quad (20)$$

$$\begin{aligned} -2a\pi_t \delta \partial\pi_t/\partial\omega_t - 2b(y_{it} - y_{it}^*)(\lambda\delta(\partial\pi_t/\partial\omega_t - 1) - \varepsilon(1 - \delta)) \\ + (1 + \rho)^{-1} dV_i^W(y_{t+1}^*)/dy_{t+1}^* \lambda\delta(\partial\pi_t/\partial\omega_t - 1) = 0 \end{aligned} \quad (21)$$

The derivatives dV^B/dy^* and dV_i^W/dy^* are non-negative if $y^* < y^{**}$.¹⁵ The first-order condition for the central bank, eq. (20), therefore implies that π must be positive if $y^{**} > y_t$ and $\beta > 0$. Turning to the union's first order condition, eq. (21) can be rewritten

$$\begin{aligned} 2a\pi_t \delta \partial\pi_t/\partial\omega_t + (1 + \rho)^{-1} dV_i^W(y_{t+1}^*)/dy_{t+1}^* \lambda\delta(1 - \partial\pi_t/\partial\omega_t) \\ = [\lambda\delta(1 - \partial\pi_t/\partial\omega_t) + \varepsilon(1 - \delta)]2b(y_{it} - y_{it}^*) \end{aligned} \quad (22)$$

By assumption a is positive and π is positive if $y^{**} > y^*$ (eq. (20)). Since

¹⁴The payoff to unions depends exclusively on current and future values of the choice variables π and ω_j , $j = 1, \dots, n$. To see this, rewrite (16) using (2)–(4)

$$V_i^W = \sum (1 + \rho)^{-t} \{-a\pi_t^2 - b[\lambda(\pi_t - \omega_t) - \varepsilon(\omega_{it} - \omega_t)]^2\}$$

The payoff to the central bank does depend on the current state as well as on current and future strategies, but the value of V^B at time zero can be written

$$V^B = \sum (1 + \rho)^{-t} \{-\alpha\pi_t^2 - \beta[y^{**} - y_0^* - \lambda \sum_{\tau=0}^t (\pi_{t-\tau} - \omega_{t-\tau})]^2\}$$

Thus, the payoff-relevant history can be represented by the scalar variable y^* (Fudenberg and Tirole, 1991, p. 514).

¹⁵In a LMPE the linear strategies $\pi = \pi(y^*, \omega)$ and $\omega = \omega(y^*)$ must take the forms $\pi = \pi_1(y^{**} - y^*) + \pi_2\omega$ and $\omega = \omega_1(y^{**} - y^*)$. Hence $V^B(y^{**}) = V_i^W(y^{**}) = 0$, and since $V^B(y^*)$ and $V_i^W(y^*)$ are non-positive and quadratic in y^* the result follows.

$dV_i^W(y_{t+1}^*)/dy_{t+1}^* > 0$ for $y_{t+1}^* < y^{**}$ and $1 \geq \partial\pi/\partial\omega > 0$ for $\beta > 0$,¹⁶ it therefore follows that the left-hand side of (22) must be positive unless $y_t > y^{**}$. The right-hand side, on the other hand, cannot be positive unless $y_{it} > y_{it}^*$. Hence we must have $y_t > y_t^*$ when $y^{**} > y_t^*$, and both y_t and y_t^* will converge to y^{**} while π converges to zero.¹⁷

The above analysis of the effects of endogenous changes in union membership is based on restrictive assumptions. One may question the simple dynamic specification of y^* (eq. (14)) or reject the specification of the objective functions in (16)–(17). Unions, for instance, may care about both employment (relative to y^*) and the level of real wages, and if the real wage target fails to change exactly in parallel with the changes in y^* , the real wage target has to be included explicitly in the unions' payoff function. Finally, one might want to consider alternative equilibrium concepts (e.g. reputational equilibria). Changes in any of these different dimensions of the model will affect the outcome. Having said this, however, the qualitative conclusion may be fairly robust, given the payoff functions (16)–(17). As long as unions care about inflation ($a > 0$) and the central bank cares about output ($\beta > 0$), one would expect reasonable specifications of the game to have the property that

$$y_t - y_t^* = f(y^{**} - y_t^*) \text{ with } f \text{ continuous and } x \geq f(x) > 0 \text{ for } x > 0 \quad (23)$$

Equations (14) and (23) are sufficient to ensure that both y_t and y_t^* converge to y^{**} for $t \rightarrow \infty$.

4. Concluding comments

The results in this paper depend on two key assumptions. The first is that wages are decided by unions and that unions—reflecting the preferences of the membership—care about inflation as well as about output and real wages. Secondly, it has been assumed that individual unions recognize the existence of a link between their wage demands and the average rate of inflation.

The link between wage demands and average inflation will be weak if unions are highly decentralized, but this weakness does not undermine the second assumption except in the limiting case of atomistic unions. The literature on policy games routinely imposes huge amounts of rationality and foresight on all agents, and it would seem distinctly *ad hoc* to introduce non-rationality assumptions at this point.

The first assumption also seems reasonable. Inflation enters the central bank's payoff function because governments dislike inflation, this government preference being in turn explained by a dislike of inflation among the electorate. A large part of the electorate consists of workers, and if anything

¹⁶ The restrictions on $\partial\pi/\partial\omega$ can be derived by differentiating the first-order condition (20).

¹⁷ The case with $a = 0$ is closely related to the analysis in Lockwood and Philippopoulos (1994). It implies a solution with $y_{it} = y_{it}^*$ and $V_i^W = 0$ (and hence $dV_i^W/dy^* = 0$).

one would expect workers to show a greater-than-average dislike of inflation. Certainly, it is implausible that workers should be completely indifferent to inflation. Rejections of the assumption therefore would seem to require a failure of the unions to reflect the preferences of the membership. Perhaps the most promising explanation for such a failure would be that the members, unlike the union officials, do not recognize the influence of their own wage settlements on inflation. Union officials therefore are judged exclusively on the outcome for employment and real wages while the central bank is held responsible for inflation. This explanation once again introduces non-rationality at a critical point.¹⁸

Overall, therefore, it seems unfortunate that Barro-Gordon type models have been so influential. The conclusions from these models are sensitive to the precise specification and, in a European context with strong unions, the basic Barro-Gordon set-up even supports policies that are the exact opposite of those normally associated with this literature: if unions are non-atomistic and inflation-averse, it is always optimal to give the central bank a pure output target, and in the dynamic game all soft banks achieve better results in the long run than strong banks with an exclusive commitment to low inflation.

One might ask finally about the empirical evidence on the relation between central-bank behaviour and economic performance. This empirical issue is beyond the scope of the present paper but, as argued by Forder (1996), many recent studies may be methodologically flawed. In the present context, it should be noted in particular that simple correlations between indicators of central-bank behaviour and performance indicators like unemployment and inflation can be greatly misleading. At the very least, allowance should be made for different structures of the labour market and differences in union preferences.¹⁹ This last point may introduce a systematic bias in the conclusions from simple correlations. A strong aversion to inflation among the general population is likely to be reflected in the preferences of unions as well as in the policies of the central bank, and it would be a mistake to ascribe the consequences of this general inflation aversion to central bank behaviour alone: if unions are inflation-averse too, countries may perform well despite a sub-optimal central-bank emphasis on price stability.

¹⁸ An alternative explanation could perhaps be constructed around the notion that workers deliberately pre-commit themselves through the setting of the criteria on which union officials will be judged. Workers, in this explanation, do care about inflation and recognize the link between wage demands and inflation, but they also recognize the dependence of the outcome of the game on the parameters a and b in the same way that the government may recognize the importance of α and β . Depending on the precise specification of this 'supergame', the choice of $a = 0$ may or may not be an optimal strategy. Aside from pushing the rationality and coordination of workers beyond the credible, this approach would seem to invite problems of infinite regress: why not analyse the even higher order game in which agents through pre-commitment affect the outcome of the pre-commitment-game?

¹⁹ Bleaney (1996) includes both central-bank independence and union structure in his regressions for inflation and unemployment. He assumes, however, that unions pay no attention to inflation.

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APPENDIX

Assume that the production function for the homogeneous output is symmetric Cobb-Douglas with n different types of labour; i.e.

$$\log Y = \gamma/n \sum_{i=1}^n \log L_i \quad (\text{A1})$$

Profit maximization then implies

$$w_i L_i = 1/n \sum_{j=1}^n (w_j L_j) \quad (\text{A2})$$

The average rates of wage inflation and employment growth can be written

$$\omega = \sum_{i=1}^n \left(w_i L_i / \sum_{j=1}^n w_j L_j \right) \omega_i = 1/n \sum_{i=1}^n \omega_i \quad (\text{A3})$$

$$\hat{L} = \sum_{i=1}^n \left(w_i L_i / \sum_{j=1}^n w_j L_j \right) \hat{L}_i = 1/n \sum_{i=1}^n \hat{L}_i \quad (\text{A4})$$

where $\hat{L}$ and $\hat{L}_i$ are the growth rates of average employment and union- i employment, respectively. Using (A3)–(A4), logarithmic differentiation of (A2) gives

$$\omega_i + \hat{L}_i = \omega + \hat{L} \quad (\text{A5})$$

Equation (A5) corresponds to (3) with $\varepsilon = 1$, $y_i = \log L_i$ and $\hat{L}_i = y_{it} - y_{it-1}$.

An alternative justification for eq. (3) could be based on differentiated outputs with each union (type of labour) being used for the production of a particular product

$$Y_i = L_i^\gamma \quad (\text{A6})$$

Assuming that demand is determined by a symmetric CES utility function, we get

$$Y_i / Y_j = (p_j / p_i)^\sigma \text{ for all } i, j \quad (\text{A7})$$

where σ is the elasticity of substitution. With competitive product markets, we have $p_j = (n/\gamma) w_j Y_j^{(1-\gamma)/\gamma}$ and the conditions (A7) imply

$$y_{it} - y_{it-1} = y_t - y_{t-1} + \varepsilon(\omega_t - \omega_{it}) \quad (\text{A8})$$

where $y_i = \log L_i$, $y = (1/n) \sum_{j=1}^n y_j$ and $\varepsilon = \gamma\sigma/(\gamma + \sigma - \sigma\gamma)$.

Turning to eq. (4), eq. (A1) implies that under symmetry ($L_i = L_j = L$)

$$Y = L^\gamma \quad (\text{A9})$$

Profit maximizing under perfect competition then implies that

$$L = m(p/w)^\lambda \quad (\text{A10})$$

where $\lambda = 1/(1 - \gamma)$ and $m = (\gamma/n)^\lambda$. Taking logs and differentiating yields the equation

$$dy/dt = d \log L/dt = \lambda(d \log p/dt - d \log w/dt) = \lambda(\pi - \omega) \quad (\text{A11})$$

which is a continuous-time version of eq. (4).