Seminar Paper No. 301

MACROECONOMIC STABILIZATION POLICY AND
TRADE UNION BEHAVIOUR AS A REPEATED GAME

by
E.J. Driffill

Paper presented at the conference on

TRADE UNIONS, WAGE FORMATION
AND MACROECONOMIC STABILITY

August 26—29, 1984

arranged in conjunction with

THE BANK OF SWEDEN TERCENTENARY FOUNDATION

INSTITUTE FOR INTERNATIONAL ECONOMIC STUDIES

University of Stockholm

Seminar Paper No. 301

MACROECONOMIC STABILIZATION POLICY AND
TRADE UNION BEHAVIOUR AS A REPEATED GAME

by
E.J. Driffill
University of Southampton

Seminar Papers are preliminary material circulated to
stimulate discussion and critical comment.

January, 1985

Institute for International Economic Studies
S-106 91 Stockholm
Sweden

1.- Introduction

It is unquestionably true that the presence of trade unions in an economy affects its macroeconomic behaviour. By attempting to maintain traditional patterns of relative wages among occupations and industries, and by resisting cuts in real wages, unions slow macroeconomic adjustment (and structural change) in response to macroeconomic shocks. It is often argued that by insulating groups of workers from competitive pressures, wage determination is less associated with market clearing than it otherwise would be. Overlapping contracts and resistance to relative wage changes thus give aggregate wage inflation momentum it would not otherwise have (see Taylor (1980), Jackman (1983)). Trade union bargaining may affect the position of the Phillips curve (Jackman and Layard (1982), Nickell (1982)). A popular argument for the increases in the NAIRU (Non-accelerating-inflation rate of unemployment) which have taken place between 1960 and 1980 in many industrialized countries where unions are "strong" is that trade unions have grown more "militant" and their bargaining behaviour has changed in some way. (This argument goes back as far as Hines (1964), at least).

The purpose of this paper is to explore a further consequence of union behaviour for aggregate employment and real wages in an economy where the government attempts to stabilize output and employment in the face of shocks to the economic system. It is argued that stabilization policy, which effectively gives the union sector the appearance, if not the substance, of a partial full-employment guarantee, will induce it to choose higher real wages, leading to a lower level of aggregate employment in the economy. Thus stabilization policy reduces aggregate employment (on average) and increases

unemployment. In the face of sustained high unemployment, governments have been tempted to seek a co-operative agreement with the trade union movement wherein the government pursues policies intended to expand employment in return for the union moderating its wage demands. A case in point is the UK in 1976 where the Callaghan government offered budgetary concessions in return for moderation in wage bargaining. The problem with this kind of voluntary agreement, a "social contract", is that, given the behaviour of the other side, each side has a temptation to cheat. Indeed, the social contract engineered by Callaghan collapsed in the winter of 1978/79 when the union movement was no longer able to restrain wage demands.

The analysis in the paper examines "social contract" outcomes and the associated temptations for the union to "cheat". The analysis then goes on to examine the extent to which any of the desirable features of the "social contract" could be rescued if the government were to use suitable incentives to remove the union's temptation to cheat.

For simplicity, the paper assumes that the labour market can be represented as the behaviour of a single union, with preferences defined on real wages and employment. (The model may be relevant to economies with several unions, and with a competitive sector in the labour market as well, providing the union effects survive in such cases. Analysis of models with several unions (e.g. Oswald, (1979)) indicates that this is likely to be true.) The analysis assumes the "monopoly union" model of wage determination, where the union chooses the real wage and the firms choose the level of

employment (Oswald (1982), Farber (1978)), rather than the "efficient bargain" model (used for example in Hall and Lilien (1979) and McDonald and Solow (1981)). Oswald (1983) discusses their relative merits.

The analysis in the paper is addressed to the real affects of union behaviour and stabilization policy. The nominal effects are not considered. In order to do this it is assumed that the union can choose real wages and that government intervention can affect the position of the aggregate demand curve for labour. (The means by which this might be done are not specified in detail.) The aggregate demand curve for labour is also affected by a random shock, which provides the motivation for having stabilization policy in the first place.

The most natural interpretation of this structure is as a model of supply shocks -- changes in productivity, or fluctuations in imported raw material prices and so on -- and supply-oriented policy -- employment taxes and subsidies, direct labour market intervention. However, the specification of the model has been kept as simple as possible consistent with the purpose at hand, and so it can be interpreted more widely than as a model of supply shocks.

The analysis emphasizes the strategic aspects of stabilization policy and wage determination. In section two of the paper, they are examined as a one-shot game. The Nash and Stackelberg non-cooperative equilibria, and cooperative equilibria are examined. The Nash and Stackelberg equilibria have the property that the stabilization policy will reduce the equilibrium level of employment in the economy, but also reduce the variance of employment. This kind of policy works, therefore, but at a price. The coope-

rative solutions are efficient -- they maximize the utility of one player given the utility of the other player.

It is argued that the Stackelberg equilibrium is the appropriate non-cooperative equilibrium since the government can determine the policy framework which the union movement has to take as given when making wage decisions.

The problem with the cooperative equilibria of the one-shot game is that without precommitment they are unenforceable and the union has an incentive to cheat, once the government has played its move. In part three of the paper, the process of policy choice and real wage choice is modelled as a repeated game. It looks in particular at the question of whether a government can get an outcome of the non-cooperative super-game which is closer to the social optimum of the one-shot game than the Nash or Stackelberg non-cooperative outcomes by punishing the union if it cheats. The analysis suggests that governments have a limited ability to achieve such a result, except in special cases.

Section four of the paper contains conclusions.

The analysis in this paper develops ideas similar to those of Calmfors (1982, 1984). It differs from them in the extent to which it emphasizes strategic behaviour. It represents an extension of work contained in an earlier paper (Driffill, 1984).

2. Government intervention and union behaviour in a single-stage game

A very simple model which attempts to capture the interaction of the behaviour of a unionized labour market and macroeconomic stabilization can be set out as follows. (This is a summary of the model in Driffill (1984).)

Assume that the behaviour of the labour market can be represented as if it were one trade union with preferences (u) defined over real wages (w) and employment (N):

$$u = u(w, N). \quad (2.1)$$

The union is assumed to face a downward sloping aggregate demand curve for labour, the position of which depends on a random factor (θ) and the extent of government intervention (G) in the labour market:

$$N = N(w, G, \theta). \quad (2.2)$$

The union is assumed to choose the real wage rate in advance of knowing the realization of the state of nature (θ), but knowing the form of the government's intervention policy.

The government is supposed to make the first move in this game by choosing the form of its stabilization policy. It is assumed that the government can intervene in response to the actual state of the economy, but that it does so according to a pre-announced rule, and that its response is conditioned only on the level of employment in the economy and not on real wages. Thus, the government's move is a choice of policy rule of the form:

$$G = G(N) \quad (2.3)$$

This structure is attractive because it allows the government to respond to the actual state of the economy through N , the actual level of employment. It therefore exercises some stabilization role, but a less than perfect one, since it cannot condition its policy on the real wage rate (w). The principal reason for including this assumption is that it appears to be realistic.

During most of the post war period, governments of industrial countries have used monetary and fiscal stabilization triggered off by the actual unemployment level, with no reference to the real wage rate, and with the aim of achieving target unemployment. Indeed, for

most of the period (until well into the nineteen seventies) policy has typically been based on Keynesian macroeconomic models in which the level of output is determined by aggregate demand and not by real wages. Even if data on real wages was available, governments were not interested in conditioning macro policy on it.

Further, one may argue that while the unemployment rate can be continuously and accurately monitored, real wage rates are more difficult to measure, and, in particular, it might be difficult to determine whether real wages had been too high to sustain full employment without the benefit of hindsight. Another argument is that governments have fiscal machinery in the form of automatic stabilizers such as tax and transfer policies which respond to the unemployment rate, but not to the real wage rate. Payments of unemployment benefits, as an example, respond not to real wages but only to the numbers unemployed. Thus the thrust of these two arguments is that even if governments wanted to condition policy on real wage rates, they would find it difficult to do so.

The time horizon for this game is the shortest period in which a well-understood, stable policy rule can be implemented. Within this, the union chooses real wages so as to maximize its expected utility.

$$w = \arg \max_{\theta} \{Eu(w, N) | N = N(w, G, \theta), G = G(N)\} \quad (2.4)$$

Finally, the state of nature is revealed, and the government intervenes appropriately.

A restriction is needed on government to ensure that G is purely stabilization policy and has no effect on average. Thus, it is assumed that:

$$E(G(N)) = 0 \quad (2.5)$$

Lastly, it is necessary to specify an objective function for the government. This will have the interpretation of the true social welfare function. In general, social welfare would be expected to depend on the amount of employment and hence output, and on the real wage rate.

In addition, if the size of the outstanding national debt affects welfare, the size of that debt and hence the current deficit would be expected to affect social welfare. Assuming that the amount of government intervention in the labour market (G) affects the size of the deficit proportionately, then G should also enter the social welfare function.

Thus, in general the social welfare function (v) will be specified as a function of w , N and G :

$$v = v(w, N, G).$$

In order to simplify the analysis, the following functional forms are used:

$$u = w - \beta(N - \bar{N})^2, \quad \beta > 0 \quad (2.1')$$

$$N = \alpha_0 - \alpha_1 w + G + \theta, \quad \alpha_0, \alpha_1 > 0 \quad (2.2')$$

$$G = \gamma(N^* - N), \quad 1 + \gamma > 0 \quad (2.3')$$

$$v = -(N - \bar{N})^2 - \phi G^2$$

The demand function for labour is assumed linear in the real wage, the government's intervention (G) and the random shock (θ). The utility function for the union is linear in w and quadratic in employment N . $\bar{N}$ is the socially optimal employment level in the economy. The government stabilizes employment around a target level N^* by offsetting any deviations from it to a degree indicated by γ . With these assumptions the variance of θ does not affect the chosen real

wage rate w . Parallel shifts in the demand function for labour cause the union to demand higher wages and lead to an unchanged mean employment level. In this sense the model gives a natural unemployment rate. The social welfare function v has been assumed quadratic in deviations of actual employment from the social optimum $\bar{N}$ with no weight on wage rates. Putting weight on wage rates would appear to be unnecessary. If wage rates enter the function as $(w - \bar{w})^2$, for example, where $\bar{w}$ is the wage at which expected employment equals $\bar{N}$, then since the equilibrium of the model is bound to lie on the labour demand schedule (2.2'), $(w - \bar{w})$ will be linearly related to $(N - \bar{N})$, and the social welfare function reduces to a function of $(N - \bar{N})$ alone.

The term $-\phi G^2$ in the social welfare function allows for the effects on policy of a cost associated with deviations from a zero deficit.

This game may be played co-operatively or non-co-operatively, and among non-co-operative solutions, the Nash and the Stackelberg solutions are the natural ones to examine first.

Consider first the behaviour of the trade union in its choice of real wage rate (w) given the government's choice of policy rule (N^*, γ) .

If the government chooses a policy (N^*, γ) the union faces a demand curve for labour

$$N = \frac{\alpha_0}{1+\gamma} - \frac{\alpha_1}{1+\gamma}w + \frac{\gamma}{1+\gamma}N^* + \frac{1}{1+\gamma}\theta \quad (2.6)$$

Consequently the union will choose a wage w which satisfies

$$w = \frac{\alpha_0 + \gamma N^* - (1 + \gamma)\bar{N}}{\alpha_1} + \frac{(1 + \gamma)^2}{2\beta\alpha_1^2} \quad (2.7)$$

and an expected employment level

$$E(N) = \bar{N} - \frac{1 + \gamma}{2\beta\alpha_1} \quad (2.8)$$

This is its best response to the government's policy rule (N^*, γ) and constitutes the union's reaction function.

The variance of employment will be

$$\text{var}N = \frac{\text{var}\theta}{(1+\gamma)^2} \quad (2.9)$$

The effect of government intervention in the economy will be to steepen the real wage/employment trade-off perceived by the union (2.6) and induce the union to choose a lower expected level of employment. It will also reduce the variance of employment, by (2.9).

Thus, stabilization policy is a mixed blessing.

This argument may offer a (partial) explanation to the stagnation part of the stagflation conundrum. The model is set up in such a way as to abstract from price level fluctuations, and so it can say nothing about inflation. But, it can offer one explanation of why attempts to stabilize employment have been associated with a movement towards higher unemployment rates as the operation of policy has become understood by economic agents. (For a fuller exposition of this argument, see Driffill (1984).)

So far the discussion has concerned the response of the union to an arbitrary intervention rule. Consider now the decision made by the government.

In a Nash equilibrium, each player plays his best strategy given the strategy played by his opponent. The union's choice of strategy is a real wage rate w .

The government's expected utility is:

$$\begin{aligned} E_{\theta}(V) &= -E_{\theta}(N - \bar{N})^2 - \phi E(G^2) \\ &= -E_{\theta} \left[\frac{\alpha_0 - \alpha_1 w + \gamma N^* + \theta}{1 + \gamma} - \bar{N} \right]^2 - \gamma^2 \phi E_{\theta} \left[N^* - \frac{\alpha_0 - \alpha_1 w + \gamma N^* + \theta}{1 + \gamma} \right]^2 \end{aligned}$$

The government maximizes its expected utility over (γ, N^*) taking as given w and also the constraint (2.5). Hence N^* is chosen so that

$E(G) = 0$ and thus:
 θ

$$N^* = \alpha_0 - \alpha_1 w \quad (2.10)$$

The objective function then reduces to:

$$E_{\theta}(v) = -(\alpha_0 - \alpha_1 w - \bar{N})^2 - \left[\frac{1}{1 + \gamma} \right]^2 \text{var } \theta - \frac{\phi \gamma^2}{(1 + \gamma)^2} \text{var } \theta$$

Maximization with respect to γ gives

$$\gamma = \frac{1}{\phi} \quad (2.11)$$

In the Nash equilibrium then, the amount of stabilization (γ) depends only on the government's aversion to unexpected budgetary imbalance (ϕ), and the employment target N^* depends on the real wage w chosen by the union.

Given the union's reaction function to government policy, (2.6) and (2.7), the real wage chosen will be

$$w = \frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1 + \gamma}{2\beta\alpha_1} \quad (2.12)$$

Thus the real wage is higher with stabilization policy than without it.

In the Stackelberg solution, the government chooses its policy rule to maximize the expected value of the utility function given

the reaction function of the union (2.7) and the constraint on the expected value of intervention (2.5).

The expected utility of the government is:

$$E(v) = - E(N - \bar{N})^2 - \phi E(G^2)$$

Since N is given by 2.6 and 2.12, we have

$$N = \bar{N} - \frac{1 + \gamma}{2\beta\alpha_1} + \frac{\theta}{1 + \gamma}$$

$$\text{and } G = \gamma(N^* - N) = \frac{\gamma}{1 + \gamma}\theta$$

Thus

$$E(v) = - \left(\frac{1 + \gamma}{2\beta\alpha_1} \right)^2 - \text{var } \theta \left(\frac{1}{(1 + \gamma)^2} + \frac{\phi\gamma^2}{(1 + \gamma)^2} \right) \quad (2.13)$$

The optimum degree of intervention is therefore given by the solution to

$$\frac{(1 + \gamma)^4}{(1 - \phi\gamma)} = (2\beta\alpha_1)^2 \text{ var } \theta$$

This implies a value of γ which lies between -1 and $1/\phi$: $-1 \leq \gamma < 1/\phi$

Notably, this implies a degree of intervention under Stackelberg which is less than $1/\phi$, the optimal degree of intervention under the Nash equilibrium.

In the case when the government puts no weight on unexpected budget imbalances ($\phi = 0$) the Stackelberg solution involves an optimum degree of intervention:

$$(1 + \gamma)^2 = 2\beta\alpha_1 \sqrt{\text{var } \theta} > 0. \quad (2.14)$$

and an expected social utility

$$E(v) = - \frac{\sqrt{\text{var } \theta}}{\alpha_1 \beta} \quad (2.15)$$

The union's expected utility level is

$$E(u) = \frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1}{\alpha_1} \left(\frac{\text{var}\theta^{1/4}}{(2\alpha_1\beta)^{1/2}} - \text{var}\theta^{1/2} \right) \quad (2.16)$$

Co-operative equilibrium in the single-stage game

To find a co-operative solution of the game, a weighted average of the utilities of the two players is maximized. Maximize with respect to w , N^* and γ ,

$$E_{\theta} [\lambda v + (1-\lambda)u] = E_{\theta} [\lambda \{-(N-\bar{N})^2 - \phi G^2\} + (1-\lambda) \{w - \beta(N-\bar{N})^2\}]$$

subject to (2.6), (2.5), and (2.3'), for $0 \leq \lambda \leq 1$

The result is:

$$w = \frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1-\lambda}{2\alpha_1^2 (\beta(1-\lambda) + \lambda)}$$

$$\gamma = \frac{1}{\phi} \left(1 + \frac{1-\lambda}{\lambda} \cdot \beta \right)$$

Thus when all the weight is put on the government's objective function ($\lambda=1$) the outcome is a wage which makes expected employment equal to the socially optimal amount: $E(N) = \bar{N}$; and the degree of intervention equals the socially optimal amount ($\gamma = 1/\phi$). This outcome is the social optimum.

By contrast, when all the weight is given to the union, ($1-\lambda=1$), the outcome is complete stabilization ($\gamma=\infty$) and the wage is higher than that which gives socially optimal employment. Expected employment is $E(N) = \bar{N} - \frac{1}{2\alpha_1\beta} < \bar{N}$ and occurs where the union's indifference curve is tangent to the labour demand schedule ($N = \alpha_0 - \alpha_1 w$) in the case of certainty and zero intervention by the government.

The co-operative outcomes might be regarded as the results of "social contracts": voluntary agreements between the government and the union. Each side behaves in a way which is not its own best

Comparison of Nash, Stackelberg and Co-operative outcomes of the one-shot game.

TABLE 1

	Degree of Intervention γ	Employment Target N^*	Real Wage Rate w	Union's Expected Utility level $E(u)$
Nash	$1/\phi$	$\bar{N} - \frac{1 + 1/\phi}{2\alpha_1\beta}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1 + 1/\phi}{2\alpha_1^2\beta}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1 - (1/\phi)^2}{4\alpha_1^2\beta} - \frac{\beta \text{var}\theta}{(1 + 1/\phi)^2}$
Stackelberg (Government leader)	$\gamma_S (< 1/\phi)$	$\bar{N} - \frac{1 + \gamma_S}{2\alpha_1\beta}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1 + \gamma_S}{2\alpha_1^2\beta}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1 - \gamma_S^2}{4\alpha_1^2\beta} - \frac{\beta \text{var}\theta}{(1 + \gamma_S)^2}$
Co-operative (Social Optimum)	$1/\phi$	$\bar{N}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} - \frac{\beta \text{var}\theta}{(1 + 1/\phi)^2}$
Co-operative (Union optimum) ($\lambda = 0$)	∞	$\bar{N} - \frac{1}{2\alpha_1\beta}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1}{2\alpha_1^2\beta}$	$\frac{\alpha_0 - \bar{N}}{\alpha_1} + \frac{1}{4\alpha_1^2\beta}$

If the government plays Stackelberg leader rather than Nash, it uses the influence of its policy rule on union behaviour by reducing the degree of intervention γ and inducing the union to pick a lower real wage. Hence the government is able to stabilize around a higher employment target.

In the social optimum, the degree of intervention γ is the same as in Nash, at the point where marginal social cost of employment variation equals that of budget deficit variation. However, the wage is reduced so that the employment target can be the socially optimal level $\bar{N}$.

If the union is allowed free rein, it would choose perfect stabilization, ignoring the social costs of budget deficit variability, and, taking into account the constraint on the expected deficit of the government, would choose a point on the labour demand curve that it faces without government intervention, but choose higher wages and less employment than in the social optimum.

response given the other's actions: the government always stabilizes more than it would like to under either Nash or Stackelberg non-co-operative solutions, and the union always chooses a lower wage rate than it would like to given the government's degree of stabilization.

When $\phi = 0$, the social optimum outcome involves complete stabilization ($\gamma = \infty$), around employment $N = \bar{N}$ with a wage $w = (\alpha_0 - \bar{N})/\alpha_1$ so that employment lies on the labour demand function with no government intervention on average.

Two observations on these results are (1) governments which care more about variability of government expenditure or deficits stabilize less, as would be expected (2) in the Stackelberg case, the government may find itself destabilizing ($-1 \leq \gamma < 0$) in order to stimulate higher mean employment and lower real wage.

Cheating in the co-operative equilibrium

The difficulty of sustaining the co-operative equilibrium is that there is a strong temptation for the union to "cheat". Given the government policy of complete stabilization ($\gamma = \infty$) in a social contract, the union's best non-co-operative response is to choose an indefinitely high real wage and corresponding utility level. In the absence of being able to make binding commitments, the union would rationally choose its best non-co-operative response in a single-stage game.

However, if the game is repeated, a number of times, the government can attempt to induce an outcome closer to the social optimum than would occur in a one-shot game, by threatening to "punish" the union for cheating, i.e., deviating from the co-operative outcome of the stage game. The next section of the paper takes up this question.

3. Non-cooperative equilibrium in a multi-stage game.

The union and the government can be viewed as playing the stage game repeatedly. In real life, the players change from time to time, typically. In democratic nations the government is apt to change or is subject to reelection periodically - at least once every 5 years in the UK, every four years in the US, and so on. The composition of union membership may change gradually and the leadership may change from time to time as the result of elections. Thus, a really satisfactory analysis of their behaviour may need to take explicit account of the probability at each stage that the game will be played one more time. An additional layer of complexity would be added if the analysis attempted to encompass the fact that these probabilities may depend on the outcome of the preceding stages of the game. The theory of the political business cycle attempts to do this. However, for the moment, consider a simpler situation where the game is played indefinitely many times by the same players.

The name "social contract" is usually used for the situation where the parties voluntarily restrain their actions for the social good. The policy being proposed here is enforced by threats of punishment for bad behaviour and so "social contract" is maybe an inappropriate name. The name "enforceable contract" might be more appropriate to this case, and will be used instead in what follows.

In the remainder of the paper it will be assumed that the weight ϕ on G^2 in the social welfare function (v) is equal to zero.

In this circumstance the socially optimal outcome for the economy involves complete stabilization ($\gamma=\infty$) around an employment level $\bar{N}$ which implies a wage $w = (\alpha_0 - \bar{N})/\alpha_1$.

In order to "punish" the union for cheating, the government must be able to monitor the union's actions (w). Thus it is assumed that in each stage of the game, the government moves first with its policy (γ, N^*) which can be made contingent only on the actual employment level (N) and not on the real wage (w). Secondly, the union sets a real wage rate. Finally nature determines the size of the shock θ . At the end of each stage, both players get full information about the play in that stage. This assumption is consistent with a variety of institutional and informational structures. First, the government may be able to observe the real wage, but lack any policy tools that would enable it to respond to anything but employment. Second, the government may not be able to monitor real wages quickly enough to be able to respond within the same stage of the game. The above assumption captures the essence of that idea in a stark and simple way.

Suppose the enforceable contract policy involves an employment target $\hat{N}$ and a degree of intervention $\hat{\gamma}$, and involves the union setting a wage such that the expected amount of government intervention is zero. This wage rate satisfies

$$\hat{w} = \frac{\alpha_0 - \hat{N}}{\alpha_1} \quad (3.1)$$

The union's welfare if it complies with the enforceable contract is:

$$\hat{u} \equiv E(u) = \frac{\alpha_0 - \hat{N}}{\alpha_1} - \beta (\hat{N} - \bar{N})^2 - \frac{\beta \text{var} \theta}{(1 + \hat{\gamma})^2} \quad (3.2)$$

The union's best non-cooperative response to the policy, however, is given by:

$$w_{\text{cht}} = \frac{\alpha_0 + \hat{\gamma} \hat{N} - (1 + \hat{\gamma}) \bar{N}}{\alpha_1} + \frac{(1 + \hat{\gamma})^2}{2\alpha_1^2 \beta} \quad (3.3)$$

and the associated employment level,

$$\bar{N}_{\text{cht}} \equiv E(N) = \bar{N} - \frac{1 + \hat{\gamma}}{2\alpha_1 \beta} \quad (3.4)$$

If the union "cheats" in this way, then it gains in utility over the compliance outcome. The gain due to cheating is:

$$T \equiv \beta \left(\hat{N} - \bar{N} + \frac{1 + \hat{\gamma}}{2\alpha_1 \beta} \right)^2 = \beta (\hat{N} - \bar{N}_{\text{cht}})^2, \quad (3.5a)$$

i.e., it is proportional to the squared difference in expected employment under compliance ($\hat{N}$) and under cheating ($\bar{N}_{\text{cht}}$).

In order to induce the union to comply with the contract, the government has to be able to threaten to punish the union if it deviates from the compliance wage rate $\hat{w}$. A punishment strategy for the government is another policy, $\tilde{N}$, $\tilde{\gamma}$, such that the union's best response to it leaves it worse off than playing the compliance wage $\hat{w}$ in response to the contract policy $\hat{\gamma}$, $\hat{N}$. Punishment involves a non-cooperative game being played in each of the stage games.

Thus, there are three ways in which each of the stage games might be played:

(1) Compliance: Government plays $(\hat{\gamma}, \hat{N})$. Union plays $\hat{w}$. The union's expected utility is $\hat{u}$.

(2) Cheating: Government plays $(\hat{\gamma}, \hat{N})$. Union plays w_{cht} . The union's expected utility is u_{cht} ,

(3) Punishment: Government plays $(\tilde{\gamma}, \tilde{N})$. Union responds with $\tilde{w}$, where $\tilde{w}$ is the best non-cooperative response to $(\tilde{\gamma}, \tilde{N})$. The union's expected utility is u_p .

The enforceable contract will be such that in the "compliance" mode of play, the value of social welfare v is higher than under the punishment strategy. However, "cheating" by the union will make social welfare lower than under either the compliance or the punishment regime.

In order to induce the union to respond to $(\hat{N}, \hat{\gamma})$ with $\hat{w}$, the government must announce a strategy as follows: in the first play of the game, and on subsequent plays, if the union responded to $(\hat{N}, \hat{\gamma})$ with $\hat{w}$ in the preceding play, then the government will play $(\hat{N}, \hat{\gamma})$. Otherwise, the government will play the punishment strategy $(\tilde{N}, \tilde{\gamma})$. Furthermore, it must be true that the expected loss resulting from being punished

$$L \equiv \frac{\delta(u - u_p)}{1 - \delta}, \quad 0 \leq \delta \leq 1 \quad (3.5b)$$

(where δ is a discount factor applied by the union to future utility, and L is the loss sustained as a result of being punished for ever) exceeds the temptation to cheat T . So we must have:

$$C \equiv L - T \geq 0$$

or

$$\frac{\delta}{1-\delta} (\hat{u} - u_p) \geq (u_{cht} - \hat{u}) \quad (3.6)$$

If this constraint is met, the union's one-period gain for cheating $(u_{cht} - \hat{u})$ is more than offset by the loss due to being punished in every future period rather than obtaining the compliance outcome, and the rational response for the union is to choose the real wage rate $\hat{w}$ implied by the contract.

The government's rational response to the possibility of cheating is to threaten to "punish" for ever, rather than for a limited period, since the threat of perpetual punishment imposes a greater future cost on the union than a finite punishment period and this enlarges the set of contracts for which the temptation to cheat is outweighed by the cost of future punishments. (See Friedman 1977, chapter 8).

The problem for the government is then to choose a social contract policy $(\hat{N}, \hat{\gamma})$ and a punishment strategy $(\tilde{N}, \tilde{\gamma})$ which maximizes expected social utility given the constraint above.

It is well known that in infinitely repeated games, even when the players have a small number of strategies among which to choose, there are many equilibria. That is even more true in the case of games where the players have a continuous choice of strategies. However, it may be possible to obtain definite results from this

model in special cases. One of the most interesting questions in this instance is: how close can the government get to achieving a social optimum by using the appropriate strategies. It may be possible to throw some light on this issue in certain cases.

Recall that the socially optimum outcome with $\phi = 0$ -- i.e. no weight on G^2 in the social welfare function v -- involves complete stabilization ($\gamma = \infty$), with a real wage $w = (\alpha_0 - \bar{N}/\alpha_1)$ and consequently an employment level $N = \bar{N}$.

If the discount factor δ equals unity, and if $\hat{u} > u_p$, then the enforceable contract can come arbitrarily close to the social optimum. This can be shown more carefully as follows. The analysis draws on a theorem of Friedman, 1977, pp. 177-180.

Suppose $\delta < 1$. Let the government choose a social contract policy $(\hat{N}, \hat{\gamma})$ such that $\hat{N} = \bar{N}$.

Then the union's expected utility level under the contract is:

$$\hat{u}(\bar{N}, \hat{\gamma}) = \frac{\alpha_0 - \bar{N}}{\alpha_1} - \frac{\beta \text{var}\theta}{(1+\hat{\gamma})^2} \quad (3.7)$$

The gain from cheating is:

$$(u_{\text{cht}} - \hat{u}) = \beta \frac{(1 + \hat{\gamma})^2}{2\alpha_1\beta} = \frac{(1 + \hat{\gamma})^2}{4\alpha_1^2\beta} \quad (3.8)$$

There is some maximal γ , call it $\gamma(\delta)$ such that the constraint (3.6) is just satisfied and at $\gamma = \gamma(\delta)$,

$$\frac{(1 + \gamma(\delta))^2}{4\alpha_1^2\beta} = \frac{\delta}{1-\delta} \left[\frac{\alpha_0 - \bar{N}}{\alpha_1} - \frac{\beta \text{var}\theta}{(1+\gamma(\delta))^2} - u_p \right] \quad (3.9)$$

for some punishment strategy such that $u_p < \hat{u}$.

Figure 1

Clearly, as $\delta \rightarrow 1$, $\gamma(\delta) \rightarrow \infty$. In that sense the social contract $(\hat{N}, \hat{\gamma}) = (\bar{N}, \gamma(\delta))$ approaches arbitrarily close to the social optimum $(\hat{N} = \bar{N}, \hat{\gamma} = \infty)$.

Thus the following theorem can be stated:

Theorem 1: If the punishment strategy imposes an expected utility on the union which is less than its expected utility under the socially optimal co-operative outcome, then the set of enforceable contracts approaches the social optimum as the discount factor approaches unity.

If the discount factor is less than one, and if the government ~~attempts to stabilize output around the socially optimal level $\bar{N}$ in the~~ social contract, then the discount rate and the available punishment strategies limit the degree of stabilization the government can achieve in it. The greatest degree of stabilization is supported by the most punitive punishment strategy (that with the lowest u_p) available. However, it is not clear that the optimal policy will involve stabilization around $\bar{N}$ in those circumstances. It may be better from the point of view of social welfare to stabilize employment more, but around a lower mean.

The following two results are proved in an Appendix. (1) The set of feasible contracts (which satisfy the constraint that the temptation to cheat T (3.5a) is less than the loss L (3.5b) is a convex set in $(\hat{N}, \hat{\gamma})$ space. A necessary (but not sufficient) condition for this set to include points where the employment target $\hat{N}$ equals the social optimum $\bar{N}$ is that the punishment strategy should give the unions a utility level u_p which is less than the utility level $\frac{\alpha_0 - \bar{N}}{\alpha_1}$ (which is the utility the unions achieve in the socially ideal contract, with complete stabilization ($\hat{\gamma} = \infty$) around the socially optimum employment

level $\bar{N}$). (2) If the locus $\{\hat{N}, \hat{\gamma} | C = 0\}$ cuts the line $\hat{N} = \bar{N}$, then there will be either a tangency, in which case the slope of the locus $(\frac{d\hat{\gamma}}{d\hat{N}}|_{C=0})$ is infinite, since the locus is vertical at such a point; or two intersections, in which case only the upper one (with the higher value of $\hat{\gamma}$) is of interest, and at that point the slope of the locus will be negative. Since the loci of the social indifference curves are horizontal at that point, the best enforceable contract has an employment target which is strictly less than $\bar{N}$. See Figure 1.

This result can be stated as:

Theorem 2: If the discount factor is less than unity, then the best enforceable contract involves less than perfect stabilization around an employment target which is less than the socially optimal level $\bar{N}$.

Two factors which influence the best enforceable contract are (1) the utility the union gets in the punishment strategy, u_p , and (2) the discount factor δ or the punishment period. It may be of interest to look at these in more detail since they have been taken as exogenously given in the preceding analysis.

Consider first the punishment strategy $\tilde{N}, \tilde{\gamma}$ which would be used by the government if the union were not to comply with the contract. The worse the situation the government could force on the union (i.e. the lower u_p), the larger the set of feasible contracts and the higher the achievable level of social utility. The government has an incentive therefore to support the contract by a savage punishment strategy, in the belief that the threat will not actually have to be carried out. However, the threatened punishment not only punishes the union, but also the government. Therefore, it may be argued that if the government's bluff were called by the union, the government would actually not use a

savage punishment (which is supposed to be imposed for ever), but would just do the best it could given a non-compliant union, and choose the Stackelberg policy.

This argument accords with the idea of "perfect equilibrium" in supergames where the set of punishment strategies is restricted to those which are credible in the sense that the player in question would actually wish to carry out the punishment if the circumstances specified for its imposition actually had arisen (see Shubik (1982), Lockwood (1983) and references therein for discussions of perfect equilibria).

Compare (A) the union's expected utility under the government's Stackelberg-leader policy, which is given by equation (2.16), with (B) its expected utility under the socially optimal co-operative outcome.

Under (B) the employment target is $\bar{N}$, the degree of intervention is infinite, and the union's expected utility is

$$\hat{u}^* = \frac{\alpha_0 - \bar{N}}{\alpha_1} \quad (3.10)$$

If (A) is strictly less than (B), then the government can threaten the union with imposition of (A) in future if the union cheats on (B). This is a credible threat because if the union behaves in a non-compliant way, the strategy in (A) maximizes the government's expected utility. Therefore the condition "(A) less than (B)" is necessary for the social optimum to be attainable in a contract enforced by credible threats.

Since (A) is less than (B) if $\sqrt{\text{var}\theta} > \frac{1}{2\alpha_1\beta}$, the result can be stated as:

Theorem 3: If the government uses its Stackelberg-leader strategy to punish non-compliance, a necessary condition for attainability of

the social optimum in an enforceable contract is:

$$\sqrt{\text{var}\theta} > \frac{1}{2\alpha_1\beta}.$$

The length of the Punishment Period

The analysis has been conducted on the assumption of an infinite punishment period with a per period discount factor $\delta (\delta \in [0,1])$. This infinite punishment period is the optimal policy in a game of perfect and complete information, and the game described here conforms to that specification. In real life, infinite punishment, with no possibility of reverting to a mutually beneficial contract once a breakdown has occurred, does not seem realistic, and it would be interesting to

look at reasons for and the effects of limited punishment periods. In a related context, Barro and Gordon (1983) postulate a finite punishment period. (In their case the punishment is imposed by the private sector of the economy on the government when it causes inflation in excess of the "social contract" inflation rate.) In Barro and Gordon, the formal model is such that the optimal punishment period is infinite, although in fact they postulate a finite one of arbitrary length.

The analysis above can incorporate a finite length punishment period. However, the analysis above does not explain why a finite length punishment period might arise. It does, however, show that the shorter the period, or, equivalently, the higher the discount rate, the smaller the set of enforceable contracts, and the further will be the best enforceable contract from the social optimum.

Possible reasons for short punishment periods or high discount rates include (1) exogenous institutional constraints, like the need for a government to seek re-election periodically, or (2) imperfect information in the game such that each side is unable to monitor

the moves made by the other side perfectly.

Consider the effects of the political environment. Suppose that a government's term of office is for five years after which there is an election. Assume that if another government is elected, then the events which take place during the present government do not influence what happens under the next regime, and that the probability of re-election is somewhere between zero and one. Then the current government has a successively weaker threat to prevent the union cheating on the contract as the election approaches. With a zero chance of re-election, a government has to pursue the non-cooperative stage-game policy. The reason is that in the last period of the term, the government has no threat to prevent cheating on a contract, and thus must play the stage-game Stackelberg policy. In the penultimate period of the term, the union knows that, however it behaves, the stage-game Stackelberg policy will be played next time, so the government has no threat. The union would clearly cheat on a contract and so the government has no option but to play the Stackelberg policy in the penultimate period. The same argument can be applied to the preceding periods. At no time can such a government with no chance of re-election beyond some date sustain a contract in a game of perfect information. This is Selten's "chain-store paradox" in a different context. (See Kreps and Wilson (1982) and Milgrom and Roberts (1982)).

Kreps and Wilson and Milgrom and Roberts show that by relaxing the assumption of complete information, it is possible for the equivalent of the "social contract" to be sustained with positive probability in a finitely repeated game. They use Kreps and Wilson's (1982) concept of "sequential equilibrium", which is a generalization of the "perfect equilibrium" concept to games with incomplete information. Backus and Driffill (1984) have applied Kreps and Wilson's analysis to a macroecono-

mic policy game similar to that employed by Barro and Gordon. It turns out that if there is doubt in the minds of private sector agents about how the government is playing the game, then it is possible for the government to manipulate its reputation for playing the game in a particular way to its advantage. It may be possible to apply that kind of analysis to the model under discussion here in the case of a finite horizon.

Consider now the effects on the game of having one or both players unable to monitor perfectly the action taken by the other.

In the analysis so far, it has been assumed that the government can monitor real wages only after the end of each stage of the game. A more extreme assumption would be that the government could never observe the real wage chosen by the union, and could observe only its own action (G) and the actual level of employment in each stage of the game. This assumption would be an appropriate simplification if the government could never acquire perfect information on the union's action.

On the union side the analogous assumption is that the union cannot directly monitor the policy $(\hat{N}, \hat{\gamma})$ implemented by the government except through the observed employment level N , and knowledge of its own real wage decision.

In this situation, each player has to make an inference about the move made by the opponent from the available information. Behaviour in this kind of environment has been studied by Green and Porter (1984). Canzoneri (1983) has applied their analysis in

a discussion of monetary policy in the US.

The strategy adopted may have the following characteristic: the union will choose a critical value of observed employment, N_{cu} such that, if it has played the social contract real wage rate $\hat{w}$, then if $N < N_{cu}$ the union will not play the social contract wage but the stage-game non-cooperative equilibrium wage for the next n_u periods. Similarly, the government will choose some critical employment level N_{cg} so that if realized employment $N < N_{cg}$, the government will not play the social contract policy, but the stage-game non-cooperative equilibrium policy for a certain number (n_g) periods afterwards. The critical employment levels and the length of the reversionary periods will be optimally chosen by each side given the choices made by the other.

This behaviour will generate periodic breakdowns of social contracts within the model.

Thus, taking explicit account of imperfect information appears to be a useful enrichment of the above analysis. It makes explicit the relation between the survival rate of social contracts and the quality of information available to the parties to it.

4. Conclusion

This paper has examined the effects of macroeconomic stabilization policy in a unionized economy, emphasizing the strategic element of stabilization policy and wage determination.

In a one-shot game, the effect of stabilization policy is to

reduce the mean level of employment in the economy, but also to reduce the variance of employment. The socially optimal degree of intervention depends on the preferences of the unions and the government, constraints (in the form of the economy's demand for labour) and the variance of the shocks hitting the economy.

If the process is modelled as a repeated game then it is possible for the government to induce the unions to accept an "enforceable contract" which is closer to the socially optimal cooperative equilibrium of the one-shot game. The government effectively offers to stabilize employment to a greater extent and around a higher average level providing the union bargains for a "low" real wage. This is the enforceable contract outcome. If the union responds by bargaining for the best wage (from the union's point of view) given this stabilization policy, then the government threatens to punish the union by reverting to a policy which imposes low utility on the unions, in future plays of the game.

If the government has a strong enough threat, and if the game is played indefinitely with no discounting of the future, then the government can impose a contract which comes arbitrarily close to the socially optimal cooperative solution of the game. A strong enough threat is any policy which imposes on the union a maximum utility level which is less than the union gets in the socially optimal cooperative solution.

If there is discounting, or if no strong enough threat (in the above sense) exists, then the set of feasible contracts does not come arbitrarily close to the ideal cooperative solution. Nevertheless, it is an improvement over the non-cooperative solution to the one-shot game.

Since a punishment policy which imposes low welfare both on the unions and on the government (i.e., society as a whole) may not be a credible threat, a perfect equilibrium of the supergame was examined. In this the credible threat is that a government, faced with actual cheating on the contract, would use the best policy rule available to it given a non-compliant response, i.e., the Stackelberg solution to the non-cooperative one-shot game. This reduces the number of possible equilibria in the supergame and reduces the set of feasible contracts. With no discounting of the future, and if the variance of the shocks hitting the economy is large enough, again it is possible to get a social contract which is arbitrarily close to the socially optimal cooperative solution to the game.

If the game were played a finite number of times then an enforceable contract is not possible in a perfect equilibrium (-- in a game with complete and perfect information). If some incompleteness of information were introduced, such that, for example, the players are not sure how each other is playing the game, then the reputations become important and a contract might be possible.

A shortcoming of this analysis is that it does not give an explanation of why enforceable contracts would break down. A possible explanation of this is imperfect monitoring by each player of the other's actions. If this consideration were introduced it would modify the strategic behaviour of the players and endogenously generate the possibility that in each play of the game one player or the other would withdraw from the contract, believing that the other player had already reneged on it. Furthermore, the "punishment period" following a breakdown of the contract is of finite length. After it is over, the players rationally attempt to re-establish the contract.

The analysis described here provides a formalization of a situation in which "social contracts" have been set up (or are being set up) in a number of countries. The UK example described in the introduction is one such case. Arguably that social contract fell apart in the end either because the union side was dissatisfied with the outcome, and, in terms of the formalism used above, felt that the government had not fulfilled its commitment under the contract, or, alternatively, because the labour government of 1974-1979 had by 1978 so little prospect of re-election that it had no effective threat to induce the union side to comply with the terms of the contract. Hence, unions attempted in the fall of 1978 and the winter of 1979 to recoup real wage gains which they had earlier foregone.

A more recent case is Argentina where the current government has proposed to the IMF to improve its trade balance by means of a "social contract", in which real wage gains are restrained in order to enable faster economic growth, as an alternative to the usual IMF remedy consisting of tight fiscal and monetary policy. In this case, the threat that the IMF can wield -- not restructuring Argentina's external debts -- should strengthen the government's hand to enforce a contract. The IMF can sustain an effective threat longer than the probable life of a single administration and also enforce a worse outcome in the event of a collapse of the contract than an internal government would be able to do.

However, there are a number of weaknesses of the analysis described above, and several ways in which it could be strengthened. As it stands, the role of specific functional forms in the results is not clear. They certainly make the analysis tractable and enable fairly definite results to be obtained. It would clearly be more satisfactory if results could be found for more general specifications.

Secondly, the union has been given a very passive role in the analysis. It was assumed that it would accept any contract imposed. (Providing it involved a greater loss through punishment than temptation through cheating.) This relies heavily on the government having a strong leadership position. It would be interesting and possibly more realistic to explore the consequences of union and government bargaining over the terms of the contract, which would further limit the government's freedom of action. Thirdly, because the specification of the model was kept to the minimum, it does not make clear why stabilization policy is a desirable activity in the first place. It may be acceptable simply to assume that

stabilization is desirable in a more conventional macroeconomic model. But in this model, where an aggregate labour demand function and union preferences are specified, there is so much microeconomic specification that a microeconomic rationale for stabilization policy ought to be included as well.

Finally, there are several ways in which the analysis could be developed. Firstly, it would be useful to develop the argument carefully for cases with more than one union and perhaps also a non-unionized part of the labour market. Secondly, the analysis could be developed for the cases where agents have incomplete or imperfect information, involving the ideas of Kreps and Wilson (1982) and Green and Porter (1984). Thirdly, in a more carefully specified model, one might attempt to include both supply and demand side shocks, and incorporate inflation, money wage adjustment and monetary policy.

APPENDIX

Consider the optimization problem for the government in Section 3 when $\delta < 1$. The constraint faced by the government is that the temptation to cheat T should not exceed the loss L sustained by the union if it does cheat. From (3.2), (3.5), and (3.6) this constraint is:

$$C \equiv T - L \leq 0$$

where

$$C = \beta \left(\frac{1 + \hat{\gamma}}{2\alpha_1\beta} + \hat{N} - \bar{N} \right) - s \left[\frac{\alpha_0 - \hat{N}}{\alpha_1} - \beta(\hat{N} - \bar{N})^2 - \frac{\beta \text{var}\theta}{(1 + \hat{\gamma})^2} - u_p \right]$$

(A1)

and s is defined as

$$s \equiv \frac{\delta}{1 - \delta}$$

s can be interpreted as the weight associated with a perpetual stream of payoffs (or punishments) starting in the next period, with a discount factor of δ , or alternatively as the weight associated with a punishment period s with a discount factor of unity. (Barro and Gordon (1983) discuss optimal policy in a repeated game framework where a "social contract" type of policy is supported by the threat of punishment for a finite period of time, rather than for ever).

Since the temptation to cheat T is always non-negative, the above constraint implies that the loss L must also be non-negative, since $C \leq 0$ implies $L \geq T \geq 0$. However, it may be useful to consider the set of all $(\hat{N}, \hat{\gamma})$ combinations which have the property that $L(\hat{N}, \hat{\gamma}) \geq 0$ separately.

In $(\hat{N}, \hat{\gamma})$ space, contours of C (defined above), T and L (temptation, and loss, respectively) can be drawn.

$T = \text{constant}$ contours are straight lines of slope

$$\left. \frac{d\hat{\gamma}}{d\hat{N}} \right|_{T = \text{constant}} = 2\alpha_1\beta$$

$L = \text{Constant}$ contours are a little more complicated.

Since

$$L = s \left[\frac{\alpha_0 - \hat{N}}{\alpha_1} - \beta(\hat{N} - \bar{N})^2 - \frac{\beta \text{Var}\theta}{(1 + \hat{\gamma})^2} - u_p \right], \quad (\text{A2})$$

setting $y = \frac{\beta \text{Var}\theta}{(1 + \hat{\gamma})^2}$,

$$y = -L/s + \frac{\alpha_0 - \bar{N}}{\alpha_1} - u_p - \frac{\hat{N} - \bar{N}}{\alpha_1} - \beta(\hat{N} - \bar{N})^2 \quad (\text{A3})$$

In $(\hat{N}, y)$ space, $L = \text{constant}$ loci are parabolas with $y = 0$ at

$$\hat{N} - \bar{N} = -\frac{1}{2\alpha_1\beta} \left[1 + \sqrt{1 + 4\beta \left(\frac{\alpha_0 - \bar{N}}{\alpha_1} - u_p - L/s \right)} \right] \quad (\text{A4})$$

and a maximum value of y where

$$\hat{N} - \bar{N} = -\frac{1}{2\alpha_1\beta}$$

Since when $y = 0$, $\hat{\gamma} = \infty$, the $L = \text{constant}$ loci in $(\hat{N}, \hat{\gamma})$ space are distorted parabolas whose arms have asymptotes given by (A4) above.

Note that if $\frac{\alpha_0 - \bar{N}}{\alpha_1} - u_p < 0$, (i.e., the punishment strategy

gives more utility than the social optimum, which consists of employment $\bar{N}$ and complete stabilization) then as $\hat{\gamma} \rightarrow \infty$, the asymptotic value of

$\hat{N}$ along the higher arm of the $L = 0$ locus is less than $\bar{N}$, and thus the social optimum is unattainable.

Loci of $T = \text{constant}$ and $L = \text{constant}$ are illustrated in Figure A1. The constraint (A1) is ultimately of most interest. Consider the contours of $C = \text{constant}$.

The slope of these loci is

$$\left. \frac{d\hat{Y}}{d\hat{N}} \right|_{C = \text{Constant}} = - \frac{\partial C / \partial \hat{N}}{\partial C / \partial \hat{Y}} \equiv - \frac{C_N}{C_Y}$$

The derivatives of C are:

$$C_N = 2\beta \left(\frac{1 + \hat{Y}}{2\alpha_1 \beta} + \hat{N} - \bar{N} \right) + s \left(\frac{1}{\alpha_1} + 2\beta(\hat{N} - \bar{N}) \right) \quad (\text{A5})$$

$$C_Y = \frac{1}{\alpha_1} \left(\frac{1 + \hat{Y}}{2\alpha_1 \beta} + \hat{N} - \bar{N} \right) - \frac{2s\beta \text{var}\theta}{(1 + \hat{Y})^3}$$

$C_N = 0$ along a locus

$$\left. (\hat{N} - \bar{N}) \right|_{C_N = 0} = - \frac{1 + \hat{Y} / (1 + s)}{2\beta\alpha_1} \quad (\text{A6})$$

$C_Y = 0$ along a locus

$$\left. (\hat{N} - \bar{N}) \right|_{C_Y = 0} = - \frac{1 + \hat{Y}}{2\beta\alpha_1} + \frac{2s\alpha_1 \beta \text{var}\theta}{(1 + \hat{Y})^3} \quad (\text{A7})$$

These loci, and the signs of the derivatives of C in the four regions of the non-negative quadrant of the $(\hat{N}, \hat{Y})$ plane are indicated in Figure A2. A $C = \text{const.}$ locus is also drawn in this diagram. The $C_Y = 0$ and $C_N = 0$ loci have been drawn in such a way that they intersect in the positive quadrant, though that need not necessarily be the case.

The locus of points $C = 0$ is clearly going to be contained in the region where $L \geq 0$, since $T \geq 0$ everywhere.

The part of the $C = 0$ locus of interest is the upper right hand quarter where the slope is negative. The feasible region for the government, the set of $(\hat{N}, \hat{\gamma})$ where $C \leq 0$ is contained inside the $C = 0$ locus.

By examining the second derivatives of C it is clear that C is a strictly convex function:

$$C_{\gamma\gamma} = \frac{1}{2\alpha_1^2\beta} + \frac{6s\beta\text{var}\theta}{(1 + \hat{\gamma})^4} > 0$$

$$C_{NN} = 2\beta(s + 1) > 0.$$

$$C_{N\gamma} = 1/\alpha_1 > 0.$$

$$C_{NN}C_{\gamma\gamma} - C_{N\gamma}^2 = \frac{2s + 1}{\alpha_1^2} + \frac{12s\beta\text{var}\theta}{(1 + \hat{\gamma})^4} > 0$$

Thus, C has a unique minimum point and the set $\{\hat{N}, \hat{\gamma} | C \leq 0\}$ is a strictly convex set.

Note that if the $C = 0$ locus passes through the locus $\hat{N} = \bar{N}$, the socially optimal output level, then, from (A5), the slope of the locus is:

$$\left. \frac{d\hat{\gamma}}{d\hat{N}} \right|_{\substack{C = 0, \\ \hat{N} = \bar{N}}} = - \frac{1 + \hat{\gamma} + s}{\left(\frac{1 + \hat{\gamma}}{2\alpha_1\beta} - \frac{2s\alpha_1\beta\text{var}\theta}{(1 + \hat{\gamma})^3} \right)} < 0$$

(The locus $C = 0$ cuts $\hat{N} = \bar{N}$ twice, unless it is tangent to it, and at the intersection with the higher value of $\hat{\gamma}$, the above is true).

Consider now the social utility function under the enforceable contract.

$$\begin{aligned}
v &= E(N - \bar{N})^2 \\
&= -(\hat{N} - \bar{N})^2 - \frac{\text{var}\theta}{(1+\hat{\gamma})^2}
\end{aligned} \tag{A8}$$

The social indifference curves in $(\hat{N}, \hat{\gamma})$ space are horizontal at $\hat{N} = \bar{N}$ and negatively sloped to the left of $\bar{N}$ (for $\hat{N} < \bar{N}$): more stabilization has to be substituted for lower mean employment to preserve a given value of social welfare.

Thus, it is clear that in the case under discussion, where s is finite (equivalently, $\delta < 1$), and where the set of feasible contracts $\{\hat{N}, \hat{\gamma} | C \leq 0\}$, is non-empty, there will be a unique optimal social contract.

Further it is clear that this optimum will involve a target employment level $\hat{N}$ which is less than the socially optimal level $\bar{N}$.

$$\text{(At } \hat{N} = \bar{N}, \text{ we have } \left. \frac{d\hat{\gamma}}{d\hat{N}} \right|_{v \text{ Constant}} = 0 \quad \text{but } \left. \frac{d\hat{\gamma}}{d\hat{N}} \right|_{C=0} < 0$$

Thus, it will be optimal to reduce $\hat{N}$ and increase $\hat{\gamma}$ along the $C = 0$ locus until:

$$\left(\left. \frac{d\hat{\gamma}}{d\hat{N}} \right|_{v \text{ Const.}} = \left. \frac{d\hat{\gamma}}{d\hat{N}} \right|_{C=0} \right).$$

Figure A1

Figure 2A

References

- Akerlof, G.A., "The market for Lemons", Quarterly Journal of Economics, 1970.
- Barro, Robert J., and David B. Gordon, "A positive Theory of Monetary Policy in a Natural Rate Model", Journal of Political Economy, 91 (4), 1983, 589-610.
- Barro, Robert J., and David B. Gordon, "Rules, Discretion and Reputation in a Model of Monetary Policy", Journal of Monetary Economics 12 (1983), 101-121.
- Backus, David K., and E.J. Driffill, "Reputation and Inflation", American Economic Review (forthcoming, 1985).
- Backus, David K., and E.J. Driffill, "Rational Expectations and Policy Credibility Following a Change in Regime", Queen's University, Kingston, Canada, Discussion Paper no 564, May 1984.
- Calmfors, Lars, "Stabilization Policy and Wage Formation in the Smaller European Economics with Strong Trade Unions", in Emerson, M., ed., Europe's Stagflation, Oxford University Press 1984.
- Calmfors, Lars, "Employment Policies, Wage Formation and Trade Unions in a Small Open Economy", Scandinavian Journal of Economics, 84 (2), 1982, 345-373.
- Calmfors, Lars, and Henrik Horn, "Classical Unemployment, Accommodation Policies and the Adjustment of Real Wages", this volume, 1985.
- Canzoneri, Matthew B., "Monetary Policy Games and the Role of Private Information", mimeo, Federal Reserve Board, Nov. 1983.
- Driffill, E.J., "Can Stabilization Policy Increase the Equilibrium Unemployment Rate?", Discussion Papers in Economics and Econometrics No. 8312, University of Southampton, March 1983. Published in G. Hutchinson and J.G. Treble (eds.), Recent Advances in Labour Economics, Croom-Helm, London, 1984.
- Friedman, James W., Oligopoly and the Theory of Games, Amsterdam: North-Holland, 1977.
- Green, Edward J. and Robert H. Porter, "Non-cooperative Collusion under Imperfect Price Information", Econometrica, 52 (1), Jan. 1984, 87-100.

- Grossman, Sanford J., and Lawrence Weiss, "Heterogeneous Information and the Theory of the Business Cycle", Journal of Political Economy, Vol. 90, No. 4, August 1982, pp. 699-727.
- Hall, R.E., and Lilien, D.M., "Efficient Wage Bargains under Uncertain Supply and Demand", American Economic Review Vol. 69, 1979, 868-879.
- Hines, A.G., "Trade Unions and Wage Inflation in the United Kingdom, 1893-1961", Review of Economic Studies, 31 (1964), 221-252.
- Jackman, Richard, "Money Wage Rigidity in a Model with Rational Trade Unions", London School of Economics, Centre for Labour Economics, Discussion Paper No. 171, 1983.
- Jackman, Richard, and Richard Layard, "Trade Unions, The NAIRU, and a Wage-Inflation Tax", London School of Economics, Centre for Labour Economics, Discussion Paper No. 100, January 1982.
- Kreps, David M., Paul Milgrom, John Roberts, and Robert Wilson, "Rational Co-operation in the Finitely Repeated Prisoners Dilemma", Journal of Economic Theory, 27, 1982, 245-252.
- Kreps, David M., and Robert Wilson, "Reputation and Imperfect Information", Journal of Economic Theory, 27, 1982, 253-279.
- Layard, P.R.G., and S.J. Nickell, "The Case for Subsidizing Extra Jobs", Economic Journal, March 1980, Vol. 90, 51-73.
- Lockwood, Ben, "Perfect Equilibria in Repeated Games with Discounting", University of Cambridge, Economic Theory Discussion Paper No. 65, June 1983.
- McDonald, I.M., and R.M. Solow, "Wage Bargaining and Employment", American Economic Review, Dec. 1981, Vol. 71, No. 5, 896-908.
- Meyer, Lawrence H., and Charles Webster, Jr., "Monetary Policy and Rational Expectations: A Comparison of Least Squares and Bayesian Learning", Cornegie-Rochester Conference Series on Public Policy, Vol. 17, Autumn 1982, Economic Policy in a World of Change, 67-97.
- Milgrom, Paul, and John Roberts, "Predation, Reputation, and Entry Deterrence", Journal of Economic Theory, 27, 1982, 280-312.

- Minford, A.P.L., "Labour Market Equilibrium in an Open Economy", Oxford Economic Papers, 1983.
- Nickell, S.J., "A Bargaining Model of the Phillips Curve", Centre for Labour Economics, London School of Economics, Discussion Paper No. 130, June 1982.
- Oswald, A.J., "Wage Determination in an Economy With Many Trade Unions", Oxford Economic Papers, 31 (1979), 369-385.
- Oswald, A.J., "The Microeconomic Theory of the Trade Union", Economic Journal, Vol. 92, No. 367 (Sept. 1982), 576-596.
- Oswald, Andrew J., "The Economic Theory of Trade Unions: An Introductory Survey", this volume.
- Sargent, T.J., and Neil Wallace, "Rational Expectations and the Theory of Economic Policy", Journal of Monetary Economics, 2 (1976), 169-183.
- Shubik, Martin, Game Theory in the Social Sciences, MIT Press, Cambridge MA, 1982.
- Spence, A.M., "Labour Market Signalling", Quarterly Journal of Economics, 1973.
- Taylor, John B., "Aggregate Dynamics and Staggered Contracts", Journal of Political Economy, 88 (February 1980), 1-23.