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Stabilization Policy, Rational Expectations and Staggered Real Wage Contracts

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Abstract

The paper deals with the controversial question of whether anticipated macro-policies have any effect on real output under rational expectations. It shows that the short run neutrality proposition originated in the new equilibrium theories of the business cycle is invalidated by staggered wage contracts that aim at a target average real wage over the contract span. These staggered “real wage contracts” generate a Phillips Curve link between the acceleration of inflation and unemployment only if their real wage target moves counter-cyclically. Furthermore, a fully anticipated monetary policy innovation has a direct impact on inflation that is not captured by the unemployment terms of the Phillips Curve.

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The new equilibrium theories of the business cycle have produced the remarkable result that anticipated macro-policies have no effect on such real aggregates as output or the unemployment rate[1]. It has been shown recently that this proposition also holds for some keynesian disequilibrium models (see Bennett McCallum and my 1981 paper), but we know that it fails to hold in models with staggered wage contracts, as shown by Stanley Fischer and John Taylor (1980). Since these models provide at the present the best theoretical rationale for policy activism, additional efforts in the direction of sharpening our understanding about them seem to be justified.

This paper deals with staggered labour contracts that are written so as to keep the expected average real wage over the contract span equal to a certain target value. These staggered real wage contracts are a sort of hybrid of the contracts studied by Stanley Fischer with those studied by Edmund Phelps and John Taylor. They have a real wage target, but otherwise differ from Fischer's contracts in having the nominal wage fixed within each contract, while Fischer assumes that the nominal wage is indexed to future price levels as expected at the time contracts are written, and therefore will not in general be constant within the contract span. In this respect staggered real wage contracts are similar to Phelps-Taylor's contracts, though the latter assume a relative wage target rather than a real wage target. There is, however, as shown in the Appendix, a perfect equivalence in the analytical consequences of these two types of contract and our results can be easily restated in terms of staggered relative wage contract The paper constructs a simple macroeconomic model for an economy with rational expectations and staggered real wage contracts. In this model there is scope for policy activism, and the optimal feedback control rule for monetary policy can be derived explicitly. Other important features of the model are that it generates a Phillips Curve relationship between inflation and unemployment only when contracts aim at a target real wage average over the contract span that is negatively related to expected employment, but this Phillips Curve has the peculiarity of being temporarily shifted by fully anticipated changes in the monetary policy rule. This last result should be emphasized as it implies that there is a direct link between money supply innovations and inflation, which is not captured by the unemployment terms of the Phillips Curve. Thus, staggered wage contracts cannot provide a rationale for a standard accelerationist Phillips Curve which is invariant with respect to policy innovations, as has been suggested, for example, by John Taylor (1979).

The argument is developed in four sections. Section I sets up a basic framework for the following discussion in the form of a simple keynesian rationale expectations model (similar to that in my 1981 paper), in which there is a fixed wage-price setting interval that defines the period of

[1] Main contributions to these theories and other references can be easily found in the volumes of collected papers by Robert Lucas and in the readings volume edited by Robert Lucas and Thomas Sargent.

analysis. In this model the economy may be thrown out of equilibrium when it is hit by some unanticipated shock, but anticipated money is neutral. Section II shows that this neutrality feature is eliminated by the introduction of staggered real wage contracts, in which case there is an optimal feedback rule for monetary policy. Section III shows that a Phillips Curve equation results from the assumption of a counter-cyclical average real wage target in labour contracts, and finally Section IV deals with monetary policy innovations.

I. A Simple Keynesian Rational-Expectations Model

We start by modelling a closed economy with the following characteristics:

(a) There is a natural "full-employment" output level, which is constant over time.

(b) There is a fixed wage and price setting time interval that defines the period of analysis. Wages and prices are fully flexible at the start of each period, but after being set they remain frozen for the rest of the period[2].

(c) Money supply may change continuously over time.

(d) Expectations are rational in the sense of Muth.

(e) Monetary authorities have no informational advantage over private economic agents.

(f) At the beginning of a given period, the values of all aggregate variables realized in the previous period belong to the common information set.

(g) The aggregate price level set at the start of each period minimizes the expected square deviation of real output from its natural level.

The simplest model of this economy has the following four equations. First, aggregate demand is given by the quantity theory equation:

(1) $$\Delta m_t + \delta_t = \Delta y_t + \Delta p_t$$

where y_t, p_t and m_t stand for the logarithms of real output, price level, and the average money supply in period t; and Δ indicates the difference operator, so that, for example, $\Delta y_t = y_t - y_{t-1}$ is (approximately) the rate of growth of real output. Velocity changes are assumed to be a white noise process δ_t. Note that the complex time-aggregation problem of associating a single money supply index to each period when money supply changes continuously over time has been side-stepped by the use of each period's average money supply as the relevant demand shift variable[3].

[2] There is no need to worry at this stage over what determines the real wage. Any theory will be equally satisfactory as long as prices and wages are fully flexible at the start of each period.

[3] It is usual in the rational expectations literature to write (1) in terms of logarithmic deviations from trend rather than in the present rate of change form. Our excuse for departing from tradition is twofold. First, it seems better to assume that the change in velocity, rather than velocity itself, is a white noise process, since there is no economic justification for a fixed natural velocity level. Second, the use of this rate of change specification greatly simplifies the argument. Note that Thomas Sargent and Neil Wallace have once used a similar formulation.

Rational expectations imply that private economic agents do not make systematic forecasting errors. If, therefore, x_t is the anticipated rate of growth of money supply, as of the end of period $t - 1$, it follows that:

(2) $\Delta m_t = x_t + \mu_t$

where μ_t is a white noise process. Hence, $x_t = E_{t-1}(\Delta m_t)$, with the operator $E_{t-s}(.)$ being used to indicate the rational expectation of a variable as calculated with information available at the end of period $t - s$.

As a measure of the degree of macroeconomic disequilibrium, we use the output gap, h_t, defined by the logarithmic deviation of real output from its natural level $\bar{y}$:

(3) $h_t = \bar{y} - y_t$

It is useful to note that this definition implies $\Delta y_t = -h_t + h_{t-1}$. The model is closed by the price setting rule:

(4) $\min_{p_t} E_{t-1}\,(h_t^2)$

which says that at the start of each period the price level is set at the value that minimizes the expected square deviation of output from its natural value.

The endogenous variables in the model are m_t, p_t, y_t and h_t; the stochastic terms, $\bar{y}$ and x_t are exogenous. We solve it by first reducing (1), (2) and (3) to:

(5) $h_t = h_{t-1} + (\Delta p_t - x_t) - \varepsilon_t = h_{t-1} + (z_t - x_t) - \varepsilon_t$

where z_t is introduced as a short-hand notation for the rate of inflation, $z_t = \Delta p_t$, and $\varepsilon_t = \mu_t + \delta_t$.

From (5) we find[4]:

$$E_{t-1}h_t = h_{t-1} + z_t - x_t$$

and $Var_{t-1}(h_t) = \sigma_\varepsilon^2$ under the simplifying assumption that ε_t is a stationary white noise process with variance σ_ε^2; hence,

(6) $E_{t-1}(h_t^2) = (E_{t-1}h_t)^2 + Var_{t-1}(h_t) = (h_{t-1} + z_t - x_t)^2 + \sigma_\varepsilon^2$

and the first order condition for a minimum in (4) is simply:

(7) $z_t = -h_{t-1} + x_t$

Substitution of (7) into (5) gives:

(8) $h_t = -\varepsilon_t$

which establishes the neutrality of anticipated money; macroeconomic disequilibrium may result from unanticipated disturbances, including monetary policy shocks (μ_t), but the anticipated component of money supply growth (x_t) has no effect on the behaviour of real output.

It is important to notice that (7) implies:

(9) $E_{t-1}h_t = 0$

[4] Using the fact that $E_{t-1}z_t = z_t$, since private agents know the true model of the economy.

which means that the price level is set at the beginning of each period at the value that will produce macroeconomic equilibrium in the period if no unforeseen event occurs. In other words, the economy is expected to be in equilibrium in each period, though single period disequilibria may result from unpredictable disturbances. Note, however, that persistent disequilibria cannot result, *ceteris paribus*, from a single random shock. Since this looks like a discrete time analogue of continuous market clearing, we call it *discrete market clearing*.

Discrete market clearing inevitably implies that anticipated money is neutral[5]. If we rewrite (5) as $h_t = E_{t-1}h_t - \varepsilon_t$, it is obvious that (8) is a direct consequence of (9). This suggests that there will be scope for policy activism only if there is some restriction on price flexibility which is stronger that the single period stickiness of this section, and makes the model inconsistent with discrete market clearing. That is exactly what staggered labour contracts do: they make the price level sticky over several consecutive periods.

II. Staggered Real Wage Contracts

Suppose labour contracts set the nominal wage for two periods ahead. At the start of any given period, half of the labour force renegotiate its nominal wage for the next two periods, while the other half must still work for one more period under the terms set at the beginning of the previous period. Let w_t be the contract wage set in period t. We follow Edmund Phelps and John Taylor in assuming that the aggregate price level is proportional to the geometric average of nominal wages over all workers[6]:

$$(10) \qquad p_t = \frac{1}{2}(w_t + w_{t-1})$$

where the proportionality factor has been set equal to unity for convenience. This equation can also be written in terms of rates of change:

$$(11) \qquad z_t = \frac{1}{2}(\Delta w_t + \Delta w_{t-1})$$

If labour contracts are written aiming at a fixed expected (geometric) average real wage over the contract span, the nominal contract wage w for period t must be consistent with:

$$(12) \qquad (w_t - E_{t-1}p_t) + (w_t - E_{t-1}p_{t+1}) = 0$$

[5] Note, however, that discrete market clearing is a sufficient, but not necessary, condition for neutrality. See my 1981 paper.

[6] There are some problems with the microeconomic rationale of this assumption which are usually sidestepped in the literature. If each half of the labour force is employed by a different set of firms, and each firm sets its price as a fixed mark-up over its nominal wage, relative prices will change whenever the aggregate price level changes, affecting the distribution of aggregate real demand among firms. A constant rate of inflation, for example, will generate continuous real demand shifts among firms. To avoid this unrealistic implication of (10), we have to assume either that the composite commodities produced by the two sets of firms are highly complementary, or that sectoral demands are functions of "permanent" relative prices, as given, for example, by two period moving averages of price ratios. As far as I know only George Ackerloff has so far made a serious attempt to model explicitly the microeconomics of staggered price setting.

where the target average real wage has been set to zero for convenience. From (10) we compute:

$$E_{t-1}p_t = \frac{1}{2}(w_t + w_{t-1}) = p_t$$

$$E_{t-1}p_{t+1} = \frac{1}{2}(E_{t-1}w_{t+1} + w_t)$$

noting that $E_{t-1}w_t = w_t$ is a consequence of the assumption that economic agents have full knowledge of the true model of the economy. Substituting these results into (12) we obtain, after rearranging terms:

(13) $E_{t-1}(\Delta w_{t+1}) = \Delta w_t$

where $E_{t-1}(\Delta w_{t+1}) = E_{t-1}w_{t+1} - E_{t-1}w_t = E_{t-1}w_{t+1} - w_t$.

It is convenient to translate (13), which is a constraint on rates of change of the nominal contract wage, into a constraint on rates of price inflation. Thus we rewrite (11) as:

(14) $\Delta w_t = 2z_t - \Delta w_{t-1}$

and use it to calculate

(15) $E_{t-1}(\Delta w_{t+1}) = 2E_{t-1}z_{t+1} - E_{t-1}(\Delta w_t) = 2E_{t-1}z_{t+1} - \Delta w_t$

Putting together (13) and (15) we get:

(16) $\Delta w_t = E_{t-1}z_{t+1}$

which can be used to rewrite (14) as:

(17) $E_{t-1}z_{t+1} - 2z_t + E_{t-2}z_t = 0$

A simple solution for this equation is:

(18) $z_t = \bar{z}$

where $\bar{z}$ is an arbitrary integration constant. A more general solution is discussed in section IV[7].

We analyse the consequences of staggered real wage contracts by adding (18) to the model of the previous section. The first thing to note is that in this case the price setting rule (4) has to be modified, as it assumes that private agents can deal with their price setting problem as a stochastic control problem, but the possibility of sequential decision making is ruled out by (18). This equation implies that agents now have to solve a single-stage decision problem, for once the value of the integration constant $\bar{z}$ is chosen, the whole time path of the aggregate price level is determined[8].

We will assume that this constant is set at the value that minimizes the unconditional expected square deviation of real output from its natural levee for every point in time, that is:

(19) $\min_{\bar{z}} E(h_t^2)$ for all t

[7] A simple inconsequential extension of the model results from adding a random "contract shock" to (12), which then becomes: (12) $(w_t - E_{t-1}p_t) + (w_t - E_{t-1}p_{t+1}) = \lambda_t$ where λ_t is a white noise process. In his 1980 paper, John Taylor has a similar random term in his relative wage contracts. In this case we have: (17a) $E_{t-1}z_{t+1} - 2z_t + E_{t-2}z_t = -\lambda_t - \lambda_{t-1}$ and, since $E_{t-1}\lambda_t = 0$ for positive values of i: (18a) $z_t = \bar{z} + \frac{1}{2}(\lambda_t + \lambda_{t-1})$.

[8] This unrealistic feature of the model of this section will disappear in the following section, when the average real wage target of contracts becomes a function of expected unemployment.

This is clearly the second best decision rule when private agents have a quadratic disutility function on deviations of real output from the natural levee, but are restrained by (18) from using a sequential decision making rule such as (4). In order to assure that this optimization problem has a solution, we also assume that the monetary policy rule is given by:

(20) $x_t = \bar{x} + gh_{t-1}$

where $\bar{x}$ is a constant which can be interpreted as a target rate of inflation[9].

Note that if $g = 0$ we have a constant money growth rule; if g is positive we have a feedback rule.

It is simple to find a solution for (19) when $(1-g)$ is assumed to be less than unity in absolute value. We substitute (18) and (20) into (5) to get:

(21) $h_t = (1-g)h_{t-1} + (\bar{z} - \bar{x}) - \varepsilon_t$

which can be expanded backwards into:

$$h_t = (1-g)h_{t-T}^T + \sum_{i=0}^{T-1}(1-g)^i(\bar{z}-\bar{x}) - \sum_{i=0}^{T-1}(1-g)^i\varepsilon_{t-i}$$

or, by letting T go to infinity:

(22) $h_t = \frac{\bar{z}-\bar{x}}{g} - \sum_{i=0}^{\infty}(1-g)^i\varepsilon_{t-i}$

From this last equation, the unconditional expectation and variance of h_t can be calculated as: $E(h_t) = \frac{\bar{z}-\bar{x}}{g}, Var(h_t) = \sigma_\varepsilon^2 \sum_{i=0}^{\infty}(1-g)^{2i}$

Hence, it follows that:

(23) $E(h_t^2) = [(Eh_t)^2 + Var(h_t)] = [\frac{(\bar{z}-\bar{x})}{g}]^2 + \sigma_\varepsilon^2 \sum_{i=0}^{\infty}(1-g)^{2i}$

which attains a minimum with respect to $\bar{z}$ when $\bar{z} = \bar{x}$[10].

[9] Though it will be seen here that (19) has a simple solution when the monetary policy rule is given by (20), it should be noted that there may be no solution for this optimization problem when monetary policy follows some other rule. When this is the case, we have to replace (19) by the minimization of some intertemporal disutility functional. See Dimitri Bertsekas for a discussion of the relationship between single stage and sequential decision making problems under uncertainty.

[10] This result is also valid when $g = 0$, though the argument in this case is slightly more complicated. Assume there is some period, say $t = 0$, in which the economy is in equilibrium (hence $h_0 = 0$). Instead of (22), write:

$$h_t = \sum_{i=0}^{t-1}(1-g)^i(\bar{z}-\bar{x}) - \sum_{i=0}^{t-1}(1-g)^i\varepsilon_{t-i}, t > 0$$

$$h_t = \sum_{i=t}^{-1}(1-g)^i(\bar{x}-\bar{z}) - \sum_{i=t}^{-1}(1-g)^i\varepsilon_{t-i}, t < 0$$

and derive:

$$E(h_t^2) = \left[\sum_{i=0}^{t-1}(1-g)^i(\bar{z}-\bar{x})\right]^2 + \sigma^2\sum_{i=0}^{t-1}(1-g)^{2i}, t > 0$$

We conclude, therefore, that (21) can be written as:

(24) $$h_t = (1-g)h_{t-1} - \varepsilon_t$$

which is not consistent with neutrality of anticipated monetary policy, as the feedback parameter g of the policy rule appears as one of the determinants of the dynamic behavior of the output gap. Note that, if g is positive, a single unanticipated disturbance will, *ceteris paribus*, produce a sequence of disequilibria, with the shape of this disequilibrium path being determined by the feedback parameter of monetary policy[11]. Obviously, an optimal stabilization policy will set this parameter equal to unity, forcing the economy to behave as in the discrete market clearing case[12], that is:

(25) $$x_t = \bar{x} + h_{t-1} \text{ implying } h_t = -\varepsilon_t$$

III. The Phillips Curve

An unappealing consequence of the model of the previous section is that the rate of inflation is constant over time, as shown by (18), and there is no room for a Phillips Curve relationship between inflation and unemployment. To avoid this, we must assume that the average real wage target in labour contracts moves counter cyclically, so that contracts are expected to provide a higher average real wage over their duration, when the unemployment rate is expected to be higher[13]. In the simplest version of this assumption, the nominal contract wage w_t for period t is given by:

(26) $$(w_t - E_{t-1}p_t) + (w_t - E_{t-1}p_{t+1}) = fE_{t-1}h_t$$

where f is a positive constant.

From this we derive the equivalent of (13) as:

(27) $$E_{t-1}(\Delta w_{t+1}) = \Delta w_t - fE_{t-1}h_t$$

and, using (15), we find:

(28) $$\Delta w_t = E_{t-1}z_{t+1} + \tfrac{1}{2}fE_{t-1}h_t$$

which is the equivalent of (16), and can be used to rewrite (26) as:

$$E(h_t^2) = \left[\sum_{i=t}^{-1}(1-g)^i(\bar{x}-\bar{z})\right]^2 + \sigma^2\sum_{i=t}^{-1}(1-g)^{2i}, t < 0$$

which attains a minimum with respect to $\bar{z}$ for all t when $\bar{z} = \bar{x}$. Though the argument in this paper always assumes that $(1-g)$ is less than unity in absolute value, it should be kept in mind that our results also apply to the case $g = 0$.

[11] With constant money growth ($g = 0$) a single unanticipated disturbance will, *ceteris paribus*, produce a permanent State of disequilibrium. This happens because the contract equation (12) makes the inflation rate constant over time, as shown by (18), and if the rate of growth of money is also constant, the real quantity of money is fixed and cannot work as a stabilizing feedback control on the unemployment rate. This paradox feature of the model can be eliminated by adding an excess demand term to the contract equation, as we do in the following section, or by adding an excess demand term to equation (10), which can be understood then as an aggregate supply function.

[12] This also makes $E(h_t^2)$ for all t, as shown by (23).

[13] Ian McDonald and Robert Solow have shown that such countercyclical movement of the contract real wage can be explained by a model of efficient bargaining in the labour market with sales-constrained firms.

(29) $E_{t-1}z_{t+1} - 2z_t + E_{t-2}z_t = -\frac{1}{2}f(E_{t-1}h_t + E_{t-2}h_{t-1})$

One solution of this last equation is[14]:

(30) $z_t = \bar{z} - \frac{1}{2}f\sum_{i=1}^{\infty}(E_{t-1-i}h_{t-i} + E_{t-2-i}h_{t-1-i})$

which implies the Phillips Curve relationship:

$$z_t = z_{t-1} - \frac{1}{2}f(E_{t-2}h_{t-1} + E_{t-3}h_{t-2})$$

or, using the fact that, from (5), $E_{t-1}h_t = h_t + \varepsilon_t$:

(31) $z_t = z_{t-1} - \frac{1}{2}f(h_{t-1} + h_{t-2}) - \theta_t$

where $\theta_t = \frac{1}{2}f(\varepsilon_{t-1} + \varepsilon_{t-2})$. This is an accelerationist Phillips Curve equation in which the demand term is the average unemployment rate over the previous two periods and the random term is a first order moving average process.

In order to gain some intuitive understanding of this link between staggered contracts with a countercyclical real wage target and the Phillips Curve, let us assume that the economy follows a perfect foresight path. Rewrite (10) as:

$$(w_{t+1} - p_{t+1}) + (w_t - p_{t+1}) = 0$$

and subtract (26) from this equation to get:

(32) $\Delta(w_{t+1} - p_{t+1}) = -fh_t$

since in this case $E_{t-1}p_{t+1} = p_{t+1}$ and $E_{t-1}h_t = h_t$. Suppose, for the sake of argument, that the output gap (h_t) is a fixed positive number. It follows that, although contracts give a fixed average real wage over their time span, as assumed in (26), from (32) the real wage $(w_t - p_t)$ for the first period of contracts will have to be falling over time. This, however, is possible only if the real wage $(w_t - p_{t+1})$ for the second period of contracts is increasing over time, which seems to imply that the rate of inflation must be falling over time (note that $\Delta(w_t - p_{t+1}) > 0$ implies $\Delta p_{t+1} < \Delta w_t$). Thus, the Phillips Curve exists because, when the output gap is different from zero, changes in the rate of inflation are needed to make the average real wage over workers $(\frac{1}{2}(w_t + w_{t-1}) - p_t)$ implied by the contract equation (26) consistent with the fixed average mark-up implicit in (10).

From (30), assuming the same monetary policy rule as before, and using (5), we obtain:

(33) $h_t = (1-g)h_{t-1} + (\bar{z} - \bar{x}) - \frac{1}{2}f\sum_{i=1}^{\infty}(E_{t-1-i}h_{t-i} + E_{t-2-i}h_{t-1-i}) - \varepsilon_t$

which is essentially similar to (21), and also implies that the unconditional expected square deviation of real output from the natural level is minimized when $\bar{z} = \bar{x}$. (A proof of this assertion is in Appendix B.) Hence, it can be rewritten as:

[14] To check this solution, note that $E_{t-2}z_t = z_t$ for all t, therefore $E_{t-1}z_{t+1} - 2z_t + E_{t-2}z_t = z_{t+1} - z_t = -\frac{1}{2}f(E_{t-1}h_t + E_{t-2}h_{t-1})$.

(34) $h_t = (1-g)h_{t-1} - \frac{1}{2}f\sum_{i=1}^{\infty}(E_{t-1-i}h_{t-i} + E_{t-2-i}h_{t-1-i}) - \varepsilon_t$

As before, an optimal stabilization policy requires setting g=l, which reduces this last equation to $h_t = -\varepsilon_t$, as in the discrete market clearing case (see Appendix B).

IV. Policy Innovations

What is the effect of a fully anticipated change in the monetary policy rule on inflation and unemployment? Suppose, for example, that the monetary policy rule is:

(35) $x_t = \bar{x}_t + gh_{t-1}$

with changes in the target rate of inflation $\bar{x}_t$ being anticipated only at the period immediately before their occurrence, that is to say, $E_{t-1}\bar{x}_t = \bar{x}_t$ but $E_{t-2}\bar{x}_t = \bar{x}_{t-1}$. How do these fully anticipated policy innovations get reflected on the equations that specify the behaviour of the output gap and the inflation rate?

To answer this question, we must go back to equation (17) in Section II. We have mentioned there that $z_t = \bar{z}$ is not a general solution for this equation. As a matter of fact, suppose there is some variable r_r with the property that $E_{t-1}r_{t+1} - 2r_t + E_{t-2}r_t = 0$; it is obvious that $z_t = \bar{z} + r_t$ is also a solution. It is trivial to check that $r_t = \frac{1}{2}(\bar{x}_t + \bar{x}_{t-1})$ satisfies this condition, hence $z_t = \bar{z} + \frac{1}{2}(\bar{x}_t + \bar{x}_{t-1})$ is a solution of (17) when the monetary policy rule is given by (20).

We find the value of $\bar{z}$ in this case by noting that from (21) we get the equivalent of (22) as:

(36) $h_t = \sum_{i=0}^{\infty}(1-g)^i[\bar{z} + \frac{1}{2}(\bar{x}_t + \bar{x}_{t-1}) - \bar{x}_t] - \sum_{i=0}^{\infty}(1-g)^i\,\varepsilon_{t-i} = \frac{\bar{z}}{g} + \frac{1}{2}\sum_{i=0}^{\infty}(1-g)^i(\bar{x}_{t-1} - \bar{x}_t) - \sum_{i=0}^{\infty}(1-g)^i\varepsilon_{t-i}$

and since, by definition, the unconditional expectation of policy innovations is zero, that is, $E(\bar{x}_t - \bar{x}_{t-1}) = 0$, it follows that:

(38) $E(h_t^2) = \frac{\bar{z}^{-2}}{g^2} + \sigma_\varepsilon^2\sum_{i=0}^{\infty}(1-g)^{2i}$

which attains a minimum with respect to $\bar{z}$ when $\bar{z} = 0$.

Thus, the equivalent of (24) in the present case is:

(39) $h_t = (1-g)h_{t-1} - \frac{1}{2}(\bar{x}_t - \bar{x}_{t-1}) - \varepsilon_t$

showing that monetary policy innovations impinge on the behaviour of the output gap as much as monetary policy shocks. More specifically, a fully anticipated permanent increase in the trend rate of growth of money supply $(\bar{x}_t)$ produces an expansionary impulse on real output.

It may also be noted that the Phillips Curve equation, given by (31) in the previous section, now becomes:

(40) $z_t = z_{t-1} - f\frac{1}{2}(h_{t-1} - h_{t-2}) + \frac{1}{2}(\bar{x}_t - \bar{x}_{t-2}) - \theta_t$

showing that a single permanent policy innovation occurring in period t will temperarily shift the Phillips Curve during periods t and $t+1$. Hence, an anticipated monetary policy innovation will have a direct effect on the rate of inflation. It seems that, under rational expectations, the hypothesis of staggered wage contracts is not sufficient to rescue the conventional notion that the impact of monetary policy on inflation can be fully captured by the unemployment terms of the Phillips Curve equation.

IV. Conclusion

This paper has addressed the controversial question of whether anticipated macro policies have any effect on real output and the unemployment rate. Its main focus has been on staggered wage contracts that aim at a target average real wage over the contract span. It has shown that these staggered real wage contracts invalidate the short-run neutrality proposition originated in the new equilibrium theories of the business cycle.

This research has also indicated that these contracts will generate a Phillips Curve relation between inflation and unemployment only if their average real wage target is positively related to the unemployment rate. Furthermore, in this contract economy, fully anticipated monetary policy innovations impinge on real output as if they were monetary policy surprises, and produce temporary shifts in an otherwise stable accelerationist Phillips Curve.

Our discussion of policy innovations, which is perhaps the main contribution of this paper, suggests a number of interesting questions that we have not been able to tackle here. What are the consequences of changes in the trend rate of growth of money supply that are anticipated several periods in advance? What are the consequences of anticipated changes in the monetary policy feedback parameter? How do private economic agents discriminate among the various possible alternative types of innovation when they perceive that there has been a change of policy regime? Further research in this area seems to be clearly subject to positive marginal returns.

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Appendix A
Staggered Relative Wage Contracts

This Appendix explores some formal equivalences between the staggered real wage contracts of this paper and staggered relative wage contracts of the kind studied by Edmund Phelps and by John Taylor (1980). An appealing rationale for these latter contracts is to assume that (in the case of two period contracts) the contract wage is set in period t aiming at a *target ratio* between the average real wages, over periods t and $t+1$, of workers that have entered a new contract at period t and of those who have not. This can be written as:

(A1) $$(w_t - E_{t-1}p_t) + (w_t - E_{t-1}p_{t+1}) = (w_{t-1} - E_{t-1}p_t) + (E_{t-1}w_{t+1} - E_{t-1}P_{t+1})$$

if, for the moment, we set the target relative wage ratio to zero. Cancelling the symmetric price terms on both sides of this equation, leads to:

(A2) $$w_t = \frac{1}{2}(w_{t-1} + E_{t-1}w_{t+1})$$

which is the simplest form of a Phelps-Taylor contract (without demand and stochastic terms).

It is a simple matter of rearranging terms in (A2) to get:

(A3) $$E_{t-1}(\Delta w_{t+1}) = \Delta w_t$$

which is the same as equation (13) in the paper. Hence, exactly the same results follow from either the relative wage contracts, given by (Al) or (A2), or the real wage contracts of the paper.

To obtain a Phillips Curve equation, we assume that the target relative wage ratio depends on the expected unemployment rate, which changes (A2) into:

(A4) $$w_t = \frac{1}{2}(w_{t-1} + E_{t-1}w_{t+1}) - \frac{1}{2}jE_{t-1}h_t$$

and (A3) into:

(A5) $$E_{t-1}(\Delta w_{t+1}) = \Delta w_t + jE_{t-1}h_t$$

In this case the equivalent of (29) in the paper is:

(A6) $$E_{t-1}z_{t+1} - 2z_t + E_{t-2}z_t = j(E_{t-1}h_t + E_{t-2}h_{t-1})$$

and the equivalent of (31) is:

(A7) $$z_t = z_{t-1} + j(h_{t-1} + h_{t-2}) - \theta_t$$

It is clear that this equation qualifies as a well-behaved accelerationist Phillips Curve only if j is *negative*, in contrast to the assumption by both Phelps and Taylor that this parameter is positive. This means that contracts must be expected to provide a better relative real wage when the unemployment rate is expected to be higher.

Appendix B

This Appendix derives equation (34) of Section III explicitly. Note that, since $E_{t-1}h_t = h_t + \varepsilon_t$, (33) may be rewritten as:

(B1) $h_t = (1-g)h_{t-1} + (\bar{z} - \bar{x}) - \frac{1}{2}f\sum_{i=1}^{\infty}(h_{t-i} + h_{t-1-i}) - \varepsilon_t - \frac{1}{2}f\sum_{i=1}^{\infty}(\varepsilon_{t-i} + \varepsilon_{t-1-i})$

Consider the following polynomials in the lag operator:

$$A(L) = L + 2\sum_{i=0}^{\infty} L^i$$

$$B(L) = \sum_{i=0}^{\infty}(1-g)^i L^i$$

$$C(L) = 1 + \frac{1}{2}fA(L)$$

$$D(L) = C^{-1}(L)B(L)C(L)$$

where we assume that $C(L)$ is invertible. Then (B1) can be written as:

(B2) $h_t = (1-g)h_{t-1} + (\bar{z} - \bar{x}) - \frac{1}{2}fA(L)h_t - \varepsilon_t - \frac{1}{2}fA(L)\varepsilon_t$

or:

(B3) $(1 + \frac{1}{2}fA(L)h_t = (1-g)h_{t-1} + (\bar{z} - \bar{x}) - (1 + \frac{1}{2}fA(L)\varepsilon_t$

which can be expanded backwards into:

(B4) $C(L)h_t = B(L)(\bar{z} - \bar{x}) - B(L)C(L)\varepsilon_t$

or equivalently:

(B5) $h_t = C^{-1}(L)\frac{(\bar{z}-\bar{x})}{g} - D(L)\varepsilon_t$

It follows that:

(B6) $E(h_t^2) = [C^{-1}(L)\left(\frac{\bar{z}-\bar{x}}{g}\right)]^2 + Var[D(L)\varepsilon_t]$

which attains a minimum with respect to $\bar{z}$ when $\bar{z} = \bar{x}$. Hence (B1) is reduced to (34).

Note that if $g = 1$, $B(L) = 1$ and, with $z = x$, (B4) becomes $h_t = -\varepsilon_t$ as in the discrete market clearing case.