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An Econometric Business Cycle Model with Rational Expectations: Policy Evaluation Results

by

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This paper evaluates alternative monetary policy proposals within the context of a quarterly econometric model of wage and price dynamics with rational expectations. When embedded in a simple macroeconomic structure for aggregate demand, these wage-price dynamics generate "business-cycle" swings in output and inflation. We assume that the objective of policy is to stabilize these business cycle swings.

From a theoretical viewpoint, monetary policy can affect the relative size of these business cycle fluctuations by determining how much of a given change in wages or prices is accommodated by a change in the money supply. However, the quantitative impact of monetary policy on these fluctuations heavily depends on whether outstanding wage contracts or simple expectations of future inflation are the predominant force behind the dynamics of inflation.[1] By evaluating policy within an empirical model which has both a reasonably detailed description of contracts and rational expectations, our eventual objective is to obtain some estimates of this quantitative effect of policy.

The econometric model we use has been derived and estimated in Taylor (1979a) but is summarized below in Section 1. In this paper we take as given the estimated values of the structural parameters of the model and consider various alternative values of the parameters of the monetary policy rule. By calculating how the reduced form parameters of the model

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change with changes in the policy rule we are able to measure the effect of policies under rational expectations. The approach is described in Section 2. Using this approach we compare policies in four different ways: first, we determine how the "stochastic equilibrium" of the econometric model is altered when the policy rule changes; second, we determine how the response of the economy to particular economic shocks is altered when different policy rules are instituted; third, we compare the actual behavior of the U.S. economy during a particular historical period (1973:1 - 1977:4) to how the economy would have behaved if alternative policy rules had been in operation during the period; fourth, we determine the employment and output behavior associated with a monetary disinflation in which the rate of the growth of the money supply is reduced either suddenly or gradually from a given historical level.

1. A Summary of the Model

The model describes the behavior of 5 endogenous variables: real output (y), the output deflator (p), the money supply (m), the unemployment rate (-e), and compensation per manhour (w). It is fit to quarterly U.S. data during the period 1961:4 - 1977:4, after a logarithmic transformation and a linear trend are removed. Hence, the model should be viewed as a description of the deviation of the various variables from secular trends. There are no explicit exogenous variables in the model. A monetary policy rule is estimated along with the other structural equations. Identification is achieved through a combination of rational expectations restrictions and the omission of particular current endogenous variables from certain equations.

The estimated structural equations of the model are:

(1) $y_t = 1.48(m_t - p_t) + u_{yt} + 1.30u_{yt-1} + 1.19u_{yt-2} + .90u_{yt-3} + .57u_{yt-4}$

(2) $p_t = \hat{w}_t + u_{pt} + .78u_{pt-1} + .63u_{pt-2} + .48u_{pt-3} + .30u_{pt-4}$

(3) $m_t = g_1\hat{p}_t + g_2\hat{w}_t - .11\hat{y}_t + u_{mt} + 1.37u_{mt-1} + 1.36u_{mt-2} + 1.22u_{mt-3} + .96u_{mt-4}$

(4) $e_t = .40y_t + u_{et} + .66u_{et-1} + .47u_{et-2} + .33u_{et-3} + .18u_{et-4}$

(5) $$w_t = .267x_t + .248x_{t-1} + .199x_{t-2} + .137x_{t-3} + .082x_{t-4} + .042x_{t-5} + .019x_{t-6} + .007x_{t-7}$$

(6) $$\begin{aligned} x_t = {} & .267\hat{w}_t + .248\hat{w}_{t+1} + .199\hat{w}_{t+2} + .137\hat{w}_{t+3} + .082\hat{w}_{t+4} + .042\hat{w}_{t+5} \\ & + .019\hat{w}_{t+6} + .007\hat{w}_{t+7} + .029\hat{e}_t + .027\hat{e}_{t+1} + .022\hat{e}_{t+2} \\ & + .015\hat{e}_{t+3} + .009\hat{e}_{t+4} + .005\hat{e}_{t+5} + .002\hat{e}_{t+6} + .001\hat{e}_{t+7} \\ & + .69u_{pt-1} + .48u_{pt-2} + .35u_{pt-3} + .22u_{pt-4} + u_{xt} \\ & - .58u_{xt-1} + .10u_{xt-2} + .17u_{xt-3} + .06u_{xt-4} \end{aligned}$$

The random vector $u_t = (u_{yt}, u_{pt}, u_{mt}, u_{et}, u_{xt})'$ is assumed to be serially uncorrelated with zero mean. The estimated variance covariance matrix of these errors is given by

$$(7) \qquad \Omega = \begin{pmatrix} 1.12? & & & & \\ .287 & .334 & & & \\ -.307 & .042 & .299 & & \\ -.040 & .045 & -.022 & .081 & \\ .003 & .043 & .062 & .023 & .259 \end{pmatrix} \times 10^{-4}$$

The first equation is a simple description of output as a function of the stock of real money balances. The dynamics of the relationship between output and real balances is approximated through the serial correlation structure rather than through lagged output or lagged real balances. This is mainly for computational convenience, but the constraints which such an approximation may place on the equation should be recognized in certain policy simulations.

The second equation is a markup equation for the price level, based on wage costs and other omitted variables. The third equation is the monetary policy rule. It describes how the monetary authorities adjust the money supply in response to expected deviations of prices, wages, and output from target secular paths. The estimated values of g_1 and g_2 are -.46 and .99 respectively. In writing down equation (3) we do not enter these specific values, since we will be concerned with varying these parameters. The central purpose of this paper is to see how variations in the policy parameters g_1 and g_2 affect the performance of the economy. Equation (4) assumes that the rate of unemployment (-e) is proportional to the percentage deviations of real output from trend.

Equations (5) and (6) describe the wage dynamics of the economy and are the main focus of the model. The variable x_t is an index of contract wages set in period t. It measures contract wage decisions for a spectrum of contracts varying in length from 1 to 8 quarters. Equation (5) indicates how the aggregate wage w_t is a weighted average of current and past contract wages, with the weights depending on the distribution of contracts by contract length. We assume that this distribution is constant over time, and obtain estimates of it during the sample period. Equation (6) is the contract wage determination equation. It states that contract wages are set relative to expectations of future wages and expectations of future labor market conditions. It is assumed that contract wages are influenced by price developments (catch-up effects) represented by the cross serial correlation in the equation for x_t. In forming expectations of future wages and employment conditions, workers and firms take account of the structure of the aggregate demand side of the economy as well as the policy rule. This means that the parameters of all equations of the model (including the serial correlation parameters) enter into the equations describing the forecasts. This interaction between equations in the model places numerous restrictions on the coefficients which must be taken into account in the estimation and policy formulation process.

For policy evaluation, equations (1) through (6) must be solved to eliminate the expectations variables. Doing so results in a 5 dimensional vector ARMA model the coefficients of which depend on the policy parameters.[2] The details of this solution procedure are given in Taylor (1979a). The general form of this ARMA system can be represented as

$$(8) \qquad A_0 z_t = A(L) z_t + B(L) u_t$$

where $z_t = (y_t, p_t, m_t, e_t, w_t)'$. The 5 x 5 matrix A_0 contains structural parameters which are assumed not to depend on the policy parameters. The matrix polynomials A(L) and B(L), which are 7th and 11th orders respectively, depend explicitly on the policy parameters. The relationship between the reduced form and the policy parameters does not have a closed form but can be evaluated numerically. This is illustrated in Tables 1 and 2.

Table 1 gives the values of the matrix polynomials A(L) and B(L) when the policy parameters are set to their estimated values along with all the other parameters in the model. These parameter values for A(L) and B(L) are the maximum likelihood estimates of the ARMA model as constrained by the rational expectations relationships between the equations, as reported in Taylor (1979a). As mentioned above the estimated values of g_1 and g_2 are -.46 and .99, respectively. When these parameter values are changed, the parameters of A(L) and B(L) will also change. For example, when g_1 is increased from -.46 to 0, representing a more accommodative policy, the parameters of A(L) and B(L) shift from those given in Table 1 to those given in Table 2. Note that most of the 172 parameters in Tables 1 and 2 change as a result of the shift in the single parameter g_1. The only parameters which do not change are the 8 exogenous serial correlation parameters in the output and unemployment equations (B(1,1) and B(4,4)). This strong interaction between policy parameters and econometric equations is due to the rational expectations assumption.

Considering first the autoregressive parameters in the wage equation A(5,5), the effect of the more accommodative policy is to raise uniformly these autoregressive weights. The moving average weights in the wage equation are also increased. As one would expect, moving to an easier monetary policy raises the coefficients of the lagged dependent variables in the wage equation and thereby increases the persistance of wages. Because of the markup relationship between wages and prices, the effect of a more accommodative policy on the price dynamics is similar to that of wages.

The B(3,2) parameters measure the impact of price changes on the money supply. These enter not only directly through the forecast of prices in the money supply rule, but also through the wage forecast in the money supply rule. The increase in the parameter g_1 has the effect of increasing the response of the money supply to price movements since the B(3,2) parameters are much higher in Table 2.

TABLE 1

Estimated ARMA Parameters (1961.4 - 1977.4)

$$A_0 y_t = A(L) y_t + B(L) u_t$$

	lag 1	2	3	4	5	6	7	8	9	10	11
A(2,5)	.359	.230	.131	.066	.028	.010	.003				
A(3,5)	.216	.138	.079	.034	.017	.006	.002				
A(5,5)	.359	.230	.131	.066	.028	.010	.003				
B(1,1)	1.300	1.189	.897	.572							
B(2,1)	.016	.024	.026	.022	.015	.009	.005	.002	.001	.000	.000
B(2,2)	1.108	1.123	1.041	.883	.362	.227	.125	.061	.024	.007	.002
B(2,3)	.025	.040	.043	.036	.025	.015	.008	.004	.001	.000	.000
B(2,4)	.017	.026	.027	.022	.015	.009	.004	.002	.001	.000	.000
B(2,5)	.376	.445	.535	.470	.337	.219	.127	.057	.031	.010	.002
B(3,1)	- .115	- .099	- .007	-.004	-.009	.005	.003	.001	.000	.000	.000
B(3,2)	.001	.002	.218	.212	.217	.136	.075	.037	.014	.005	.001
B(3,3)	1.188	1.142	.891	.574	.015	.009	.005	.002	.001	.000	.000
B(3,4)	.010	.016	.016	.013	.009	.005	.003	.001	.000	.000	.000
B(3,5)	.226	.267	.321	.282	.202	.131	.076	.034	.019	.006	.001
B(4,4)	.656	.430	.282	.185							
B(5,1)	.016	.024	.026	.022	.015	.009	.005	.002	.001	.000	.000
B(5,2)	.326	.511	.562	.508	.362	.227	.125	.061	.036	.007	.002
B(5,3)	.025	.040	.043	.036	.025	.015	.008	.004	.001	.000	.000
B(5,4)	.017	.026	.027	.022	.015	.009	.005	.002	.001	.000	.000
B(5,5)	.376	.445	.535	.470	.337	.219	.127	.057	.031	.010	.002

Note: Each column represents a matrix coefficient stacked by rows from the matrix polynomial A(L) or B(L). If a component is not listed then the coefficients corresponding to that component are constrained to zero for all lags. If there is no entry for a listed component, then that coefficient is constrained to zero.

TABLE 2

ARMA Parameters with More Accommodative Policy ($g_1 = 0$, $g_2 = .99$)

Lag

	1	2	3	4	5	6	7	8	9	10	11
A(2,5)	.429	.270	.152	.075	.032	.011	.003				
A(3,5)	.425	.268	.150	.074	.032	.011	.003				
A(5,5)	.429	.270	.151	.075	.032	.011	.003				
B(1,1)	1.300	1.189	.897	.572							
B(2,1)	.018	.028	.029	.025	.017	.010	.005	.003	.001	.000	.000
B(2,2)	1.170	1.215	1.135	.961	.415	.259	.142	.069	.026	.008	.002
B(2,3)	.029	.046	.048	.040	.028	.017	.009	.004	.002	.000	.000
B(2,4)	.020	.029	.030	.025	.017	.010	.005	.002	.001	.000	.000
B(2,5)	.375	.484	.594	.526	.379	.246	.142	.065	.034	.010	.002
B(3,1)	-.107	-.086	-.057	-.030	.017	.010	.005	.003	.001	.000	.000
B(3,2)	.495	.684	.718	.634	.411	.257	.141	.068	.026	.008	.002
B(3,3)	1.202	1.163	.914	.592	.028	.017	.008	.004	.001	.000	.000
B(3,4)	.020	.029	.030	.025	.017	.010	.005	.002	.001	.000	.000
B(3,5)	.372	.480	.588	.520	.375	.244	.141	.064	.034	.011	.002
B(4,4)	.656	.430	.282	.185							
B(5,1)	.018	.028	.029	.025	.017	.010	.005	.003	.001	.000	.000
B(5,2)	.388	.603	.656	.587	.415	.259	.142	.069	.026	.008	.002
B(5,3)	.029	.046	.048	.040	.028	.017	.009	.004	.002	.000	.000
B(5,4)	.020	.029	.030	.024	.017	.010	.005	.002	.001	.000	.000
B(5,5)	.375	.484	.594	.526	.379	.246	.142	.065	.034	.011	.002

2. Policy Evaluation of Alternative Money Supply Rules.

In this section we consider three alternative ways of comparing the performance of the estimated economy under different policy regimes. First, we consider how the economy would behave over an extended period of time by evaluating the equilibrium distribution of the endogenous variables as a function of the policy parameters. This distribution indicates how the economy would operate if subject to random shocks with the same distribution as those observed during the 1961:1 - 1977:4 sample period. Since we have normalized the endogenous variables to have zero means, we focus on the steady-state covariance matrix of the equilibrium distribution.

2.1 Steady State Covariance Matrix of the Endogenous Variables

From equation (8) we have that

$$(9)\quad z_t = A_0^{-1}A(L)z_t + A_0^{-1}B(L)u_t$$

$$= [I - A_0^{-1}A(L)]^{-1}A_0^{-1}B(L)u_t$$

$$= \sum_{i=0}^{\infty} \theta_i u_{t-i}$$

where the matrix series θ_i is a function of A_0, $A(L)$, and $B(L)$ and hence is a function of g_1 and g_2. The steady state covariance matrix of the vector of endogenous variables z_t is therefore equal to

$$(10)\quad V(g_1,g_2) = \sum_{i=0}^{\infty} \theta_i \Omega \theta_i'$$

where Ω is the variance covariance matrix of the serially uncorrelated shocks u_t.

If the system (8) is stable, (10) is a convergent series and hence can be evaluated to within any desired level of accuracy.

We will focus primarily on the diagonal elements of V, the variance of the steady state distribution of each endogenous variable. Table 3 shows these diagonal elements in percentage standard deviation units. Recall that each variable is measured as a deviation from secular trend; for example, when $g_1 = 0$ and $g_2 = .99$, the case illustrated in Table 2, the standard deviation of output around trend is 1.5 percent.

Most of the variation in the policy parameters in Table 3 is confined to g_2, with g_1 held to zero. The reason for this is that the <u>sum</u> of g_1 and g_2 is quantitatively more important than the individual values. This is illustrated by comparing the results when $g_1 = 0$ and $g_2 = .50$ with $g_1 = -.46$ and $g_2 = .99$. The steady state distribution is the same in both cases, and the sum $g_1 + g_2 = .5$ in both cases. The same results follow from comparing the last two rows in Table 3. Evidently, the total degree of accommodation is more significant in this model, than the differential accommodation between prices and wages. This result reflects both the markup assumption we have used for determining prices and the nature of the feedback of prices into the wage equation.

In any case, because only the sum of g_1 and g_2 is important, most of the policy comparisons in Table 3 consider only variations in g_2. Alternative policies range from almost full accommodation in the top row of Table 3 to no accommodation in the last two rows. As policy moves in a less accommodative direction the variability of real variables--output and unemployment--

increases, while the variability of the nominal variables--prices, wages, and the money supply--increases. The estimated policy (g_1 = -.46 and g_2 = .99) is half-way between these two extremes.

Focusing on σ_y and σ_p it is clear that small changes in policy in either direction from the estimated policy, lead to point-for-point changes in output variability and price variability. That is, when the standard deviation of output increases by .1 percent, the standard deviation of prices falls by .1 percent. This may seem paradoxical in the sense that wages and prices are "sticky" in this model so that changes in money should result in more of a change in output than in prices. The paradox is resolved by noting that the standard deviation of these variables measures their behavior on average over a long period of time. In the short run wages and prices may be rigid but in the long run they adjust. Measures of economic performance such as the standard deviation in the steady state distribution combine these two features.

Note that this point-for-point tradeoff changes as the policy parameters move away from the estimated policy. At the extreme of a very accommodative policy, reductions in output variability are accompanied by very large increases in price variability. Similarly, at the extreme of non-accommodation, more price stability is very costly in terms of increased output variability.

It should be emphasized that other properties of the equilibrium distribution are also important for evaluating policy. The spectral density matrix--not shown here--would show how much of the change in variance occurs at low versus high business cycle frequencies. In this model it can be shown that much of the reduction in price variance which comes from a tighter monetary policy occurs at the low frequencies. That is, tighter policy reduces the variance and the persistence of prices. Some of these properties of the model are evident in what follows.

2.2 Comparison of Policies during the 1973:1 - 1977:4 Period

Comparative policy analysis in econometric models is usually achieved by simulating alternative paths for the policy variables in the reduced form of the model over some historical period. The steady-state covariance matrix presented above is conceptually different from such comparisons since it is not restricted to a particular episode. In effect the performance of the economy is evaluated over some arbitrary period with the shocks generated by the distribution of the residuals in each equation. In this section we address the policy evaluation problem in a way which corresponds more closely with the usual approach by asking how the economy would have performed in the mid-1970s if alternative policy rules had been in operation at the start of the simulation period and had been maintained throughout.

Technically, this is done by simulating the model with the actual estimated shocks in each equation in each time period, but with different policy rules determining the response of the money supply to these shocks. We consider two alternatives to the estimated policy: a more accommodative policy with $g_1 = 0$ and $g_2 = .99$ and a less accommodative policy with $g_1 = 0$ and $g_2 = 0$. These alternative policies correspond to the first and last rows of Table 3.

The results of this comparison are presented in Tables 4 and 5. The inflation effects of the different policies are shown in Table 4 while the output effects are shown in Table 5. As before, output is measured as a

TABLE 3

Effect of Policy Parameters on the Behavior of the Endogenous Variables

g_1	g_2	σ_y	σ_p	σ_m	σ_u	σ_w
.0	.99*	1.5	8.8	8.8	0.5	8.7
.0	.95	1.5	6.0	5.8	0.5	5.8
.0	.90	1.6	5.0	4.6	0.5	4.8
.0	.85	1.7	4.5	4.0	0.6	4.3
.0	.80	1.7	4.1	3.5	0.6	3.9
.0	.75	1.8	3.9	3.2	0.6	3.7
.0	.70	1.9	3.7	3.0	0.7	3.5
.0	.65	2.0	3.6	2.7	0.7	3.3
.0	.60	2.1	3.4	2.5	0.8	3.2
.0	.55	2.2	3.3	2.4	0.8	3.1
.0	.50	2.3	3.2	2.2	0.8	3.0
-.46*	.99*	2.3	3.2	2.2	0.8	3.0
.0	.45	2.4	3.1	2.1	0.9	2.9
.0	.40	2.5	3.1	1.9	0.9	2.8
.0	.35	2.5	3.0	1.8	0.9	2.7
.0	.30	2.6	2.9	1.7	1.0	2.6
.0	.25	2.7	2.9	1.7	1.0	2.6
.0	.20	2.8	2.8	1.6	1.0	2.5
.0	.15	2.9	2.8	1.5	1.1	2.5
.0	.10	3.0	2.7	1.5	1.1	2.4
.0	.05	3.0	2.7	1.4	1.1	2.4
.0	.0	3.1	2.7	1.4	1.2	2.3
-.46*	.50	3.1	2.7	1.4	1.2	2.4

Note: The policy parameters g_1 and g_2 are the elasticities of the money supply with respect to prices and wages, respectively, as given by the policy rule. The σ parameters are the standard deviations (in percent) evaluated at the equilibrium distribution as a function of these policy parameters. The asterisk represents the estimated value of the policy parameter during the sample period 1964:1 - 1977:4.

deviation from a secular trend. For each of the policies a tradeoff between higher inflation and higher output levels is evident. (Such a tradeoff does not exist in the long run, however. It appears here because only a single episode is considered.) For the estimated policy the rate of inflation averaged 6.9 percent over the 4 years ending in 1977:4, while output averaged 2.9 percent below normal. The more accommodative policy cuts this output loss to zero but results in a much higher rate of inflation (8.8 percent), which is accelerating rapidly at the end of the simulation period. The less accommodative policy increases the output loss and has a corresponding reduction in the rate of inflation.

The inflation reduction that is associated with the less accommodative policy as compared with the actual policy, is somewhat more than implied by many econometric models without rational expectations or without an explicit model of contracts. A consensus estimate is that "the cost of a 1 point reduction in the basic inflation rate is 10 percent of a years GNP" (Okun, 1978). According to the columns of Tables 4 and 5, if real output averaged 2 percent below the actual performance, inflation would have averaged one percentage point lower. If output had been 3 percent higher, inflation would have been about 1-1/2 percent higher on average. Additional results on the real effects of disinflation are presented in Section 3 below.

2.3 Effect of Unanticipated Shocks

A third way to compare the alternative policy rules is to examine how the economic system behaves when subject to particular isolated shocks. This

TABLE 4

Inflation Effects of Alternative Policy Rules 1973:2 - 1977:4
(quarterly percent change in the GNP deflator, S.A.A.R.)

	Estimated Policy	More Accommodative Policy	Less Accommodative Policy
73:2	7.0	6.0	6.4
73:3	7.4	6.7	6.6
73:4	8.6	8.8	8.4
74:1	8.7	7.9	7.2
74:2	9.8	10.8	10.0
74:3	12.2	11.6	10.0
74:4	13.5	12.8	10.8
75:1	8.5	11.6	8.8
75:2	4.3	7.6	4.3
75:3	7.1	8.8	5.9
75:4	6.6	7.6	4.8
76:1	3.9	5.2	2.9
76:2	4.7	6.4	3.6
76:3	4.5	6.4	3.6
76:4	5.7	7.4	4.4
77:1	6.0	7.8	4.8
77:2	7.7	11.6	6.4
77:3	5.1	7.6	3.9
77:4	5.5	10.4	6.8
4 quarters ending:			
74:4	11.1	10.7	9.5
75:4	6.6	8.9	6.0
76:4	4.7	6.4	3.6
77:4	6.1	9.3	5.4
4 years ending:			
77:4	7.1	8.8	6.1

Note: For the estimated policy $\hat{g}_1 = -.46$ and $\hat{g}_2 = .99$.
For the more accommodative policy $g_1 = 0$ and $g_2 = .99$.
For the less accommodative policy $g_1 = 0$ and $g_2 = 0$.

TABLE 5

Output Effects of Alternative Policy Rules 1973:2 - 1977:4
(percent deviation of real GNP from secular trend)

	Estimated Policy	More Accommodative Policy	Less Accommodative Policy
73:2	3.9	2.1	4.0
73:3	3.5	2.0	3.3
73:4	3.2	1.9	2.7
74:1	1.3	0.6	1.0
72:2	0.0	-0.1	-0.4
74:3	-1.5	-0.3	-2.0
74:4	-3.7	-1.7	-4.8
75:1	-6.9	-3.9	-8.7
75:2	-6.3	-2.5	-8.6
75:3	-4.6	-1.4	-7.2
75:4	-4.8	-1.3	-6.7
76:1	-3.4	0.1	-4.8
76:2	-3.3	0.7	-4.8
76:3	-3.5	0.8	-5.3
76:4	-3.8	0.2	-6.2
77:1	-2.9	1.3	-5.4
77:2	-2.3	2.4	-5.2
77:3	-1.7	3.4	-4.9
77:4	-2.5	2.7	-5.8
average for 4 years ending			
1977:4	-3.1	0.1	-5.1

Note: See Table 4 for the specific parameter values associated with each policy.

comparison complements the analysis of Sections 2.1 and 2.2 by abstracting from the possible interaction of shocks and by tracing out the dynamic response of the system. We have experimented with shocking the system with both temporary and permanent shocks to each equation. To keep the analysis from becoming too lengthy we focus on temporary wage shocks in this section, and examine only the output and price responses.

Table 6 shows the response of the system to a temporary wage shock under the same 3 alternative policy regimes examined in Section 2.2. Three general properties of the model and the policies are worth emphasizing. First, the gradual impact of a wage shock on both prices and output is evident in Table 6. The peak effect of the shock occurs after 4 quarters for the estimated policy and the less accommodative policy, and after 7 quarters for the more accommodative policy. This gradual impact is due to the staggered wage contracts: it takes several periods before a shock passes through the several levels of contracts.

Second, note that the persistence of the wage shock depends very heavily on which policy is being used. For the more accommodative policy the wage shock is still above the peak of the other two policies after 25 quarters and is diminishing very slowly. The persistence of the price behavior is mirrored by the output behavior. Although the depth of the downturn is much lower for both the estimated and the less accommodative policies, these downturns do not last as long. Moreover, after 20 quarters the other two policies "overtake" the less accommodative policy and result in higher output levels.

Finally, Table 4 indicates very clearly the difference between the long-run and the short-run effects of policy. These were mentioned in

Section 2.1 as an explanation for the point-for-point tradeoff between the standard deviations of output and prices. In the short run a comparison of the three policies shows how the temporary rigidity of wages implies that output takes the major effect of a tighter monetary policy. The main difference between the three policies in the first several quarters shows up in output rather than prices. However, in the longer run most of the difference is found in price behavior rather than output behavior. Comparing rows 1 and 25 of Table 6 shows this effect most dramatically.

TABLE 6

Effect of an Unanticipated Temporary Wage Shock
(Shock equals ten percent in initial quarter, zero thereafter)

Quarter	Estimated Policy		More Accommodative Policy		Less Accomodative Policy	
	y	p	y	p	y	p
0						
1	-4.2	7.0	-1.1	7.7	-8.5	6.7
2	-5.3	9.0	-1.5	10.5	-10.5	8.3
3	-6.6	11.1	-1.9	13.7	-12.8	10.1
4	-7.2	12.1	-2.2	15.6	-13.5	10.6
5	-7.1	12.0	-2.3	16.5	-13.0	10.2
6	-6.9	11.6	-2.4	16.8	-12.1	9.5
7	-6.4	10.8	-2.4	16.9	-10.9	8.5
8	-5.9	9.9	-2.3	16.7	-9.5	7.5
9	-5.4	9.1	-2.3	16.5	-8.5	6.6
10	-4.9	8.3	-2.2	16.3	-7.4	5.8
11	-4.5	7.6	-2.2	16.0	-6.5	5.1
12	-4.1	6.9	-2.2	15.8	-5.7	4.4
13	-3.8	6.3	-2.2	15.6	-5.0	3.9
14	-3.4	5.8	-2.1	15.4	-4.3	3.4
15	-3.1	5.3	-2.1	15.2	-3.8	3.0
16	-2.9	4.9	-2.1	14.9	-3.3	2.6
17	-2.6	4.4	-2.0	14.7	-2.9	2.3
18	-2.4	4.1	-2.0	14.5	-2.6	2.0
19	-2.2	3.7	-2.0	14.3	-2.3	1.8
20	-2.0	3.4	-2.0	14.1	-2.0	1.6
21	-1.8	3.1	-1.9	13.9	-1.7	1.4
22	-1.7	2.8	-1.9	13.8	-1.5	1.2
23	-1.5	2.6	-1.9	13.6	-1.3	1.0
24	-1.4	2.4	-1.8	13.4	-1.2	0.9
25	-1.3	2.2	-1.8	13.2	-1.0	0.8

Note: See Table 4 for the specific parameter values associated with each policy.

3. The Real Effects of a Monetary Disinflation

The three types of policy evaluation presented in the previous section have a common feature: they take the target rate of inflation as given and consider how different monetary policies influence the deviation of actual prices from this target trend. In this section we consider the problem of changing an historically given trend inflation rate, and the output effects that are associated with such a change.

Consider a situation in which the rate of inflation is viewed as too high, and the objective of monetary policy is to bring this inflation rate to a lower level--to disinflate the economy. Clearly, disinflation requires a reduction in the rate of monetary growth. The important question is how fast this reduction in money growth should be. The "gradualist" proposal is that the reduction in money growth should be slow. One rationale for the gradualist approach is that outstanding contracts--such as the contracts described in the model discussed here--will translate a sudden reduction in money growth into a large loss in output and employment. A gradual reduction in money growth will give some time for contracts to adjust.[3]

The output effects associated with an announced program of monetary disinflation--either gradual or sudden--can be evaluated using the model of this paper by changing the money supply rule to the following simple form:

$$m_t = [(1 - L^2)\ (1 - kL)]^{-1}\ (1 - k)\ u_{mt}\ .$$

where the disturbance term u_{mt} is serially uncorrelated. An announced monetary disinflation (unanticipated before the announcement date) can be characterized by a particular realization of the disturbance process u_{mt} .

For example, if u_{mt} equals -.0025 in quarter t=1 and zero thereafter, then a permanent one percent (annual rate) reduction in money growth begins in quarter t=1 and is perfectly anticipated starting at that time. If k = 0 then the one percent reduction in money growth occurs entirely in the first period. If k is greater than zero then the reduction is gradual; more specifically it is phased-in geometrically.

Table 7 shows the effects of such a monetary disinflation for values of k equal to 0 and .5 . It is assumed that the previous rate of inflation was 10 percent and that all other shocks to the model are set to zero during the disinflation. Hence, the important question about future accommodation is ignored. The new target rate of inflation is 9 percent.

When the disinflation is immediate, the output loss is larger than with the gradualist policy. Although the rate of inflation does not reach 9 percent as quickly under the gradualist path, there is not as much overshoot before the inflation rate settles at the new equilibrium. Overall, the advantages of a gradualist policy as compared to a more sudden change in money growth are clearly illustrated in this comparison. The total output loss associated with the sudden one percent disinflation is about 4-1/2 percent of GNP. The gradualist policy cuts this loss in half.

TABLE 7

Inflation and Output Effects of a One Percentage Point Reduction in Money Growth
(growth at annual rates)

Immediate Reduction in Money Growth

Quarter	Money Growth Rate	Inflation Rate	GNP gap (percent)
0	10.00	10.00	.00
1	9.00	10.00	.37
2	9.00	9.32	.50
3	9.00	9.07	.52
4	9.00	8.93	.50
5	9.00	8.85	.44
6	9.00	8.85	.38
7	9.00	8.86	.33
8	9.00	8.87	.29
9	9.00	8.90	.25
10	9.00	8.91	.21
11	9.00	8.92	.18
12	9.00	8.93	.15

Gradual Reduction in Money Growth

Quarter	Money Growth Rate	Inflation Rate	GNP gap (percent)
0	10.00	10.00	.00
1	9.50	10.00	.19
2	9.25	9.39	.24
3	9.12	9.16	.25
4	9.06	9.03	.24
5	9.03	8.95	.21
6	9.02	8.93	.18
7	9.01	8.94	.15
8	9.01	8.94	.13
9	9.00	8.95	.11
10	9.00	8.96	.09
11	9.00	8.97	.08
12	9.00	8.97	.07

3. Concluding Remarks

The purpose of this paper has been to compare alternative monetary policy rules in a small econometric business cycle model. While many types of policy problems could be addressed within this framework, our analysis has focussed primarily on how different degrees of monetary accommodation affect the behavior of real variables versus nominal variables. Since the model contains both rational expectations and an explicit process for the determination of wage contracts, it is especially suited for this type of comparison.

The particular results of this analysis should be interpreted cautiously because the aggregate demand side of the model is extremely simplistic. Nevertheless, the implications of these particular simulations are suggestive of what might be achieved through further research along these lines. To summarize these results: (1) Small changes in the policy rule which was estimated to have been in operation during the 1961:1 - 1977:4, result in point-for-point changes in the variability of output and prices. The short-run rigidity of wages is largely offset by their long run flexibility, when decomposing the output-price stability effects of policy; (2) Although easier monetary policy does reduce the depth of recessions it tends to increase their length. The model suggests that 5 years after a price shock sets off a recession, a tighter monetary policy would lead to output levels which are higher than easier policies; (3) The tradeoff between output and inflation which is implicit in the comparison of these models is considerably more favorable--in the sense that smaller output reductions are associated with a given reduction in inflation--than current econometric models without rational expectations or explicit wage contracts would suggest.

Footnotes

1. Another important determinant of the quantititive effect is the _credibility_ of the policy (see Fellner (1979) or Taylor (1979b) for a review of this credibility factor). We are abstracting from credibility problems in this analysis by assuming that expectations are rational.

2. This dependence is what Lucas (1976) emphasized in his critique of conventional methods of policy optimization.

3. Another reason for gradualism is that it takes time for people to learn about a new policy regime. In other words, gradualism reduces the suprise element in a radically new approach to monetary policy.

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