Employment Distortions Under Sticky Wages and Monetary Policies to Minimize Them

by James G. Hoehn

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Introduction

A major problem that monetary authorities must address is that contracts are made in nominal terms. During the contract interval, the terms may become inappropriate and cause misallocations if one of the parties has discretion over activity levels.

The prototype case emphasized by macroeconomists is that of the labor contract, which may run for three years, during which the nominal wage is stuck, despite changes in the marginal productivity and disutility of labor caused by various events. Employers have some discretion over employment levels and can improve profits by adjusting employment in response to changes in the state of the economy. The profit-maximizing employment level will not, generally, be the same as the socially optimal level because the wage is stuck and does not perfectly reflect changes in the disutility of labor. An optimal monetary policy has the effect of tending to make the real wage match the marginal disutility of work in various states of the economy.

This article explores how the money supply can be manipulated by the Federal Reserve to keep the real wage close to the marginal disutility of work in various states of the economy, and thereby minimize social welfare losses associated with the employment distortions arising from sticky wages. The primary contribution of the analysis is to provide a social welfare metric defined in terms of the outcomes of an IS-LM Phillips Curve model. Simulations are run to compare the social loss under various monetary policies, including the one that is optimal in the model, as well as policies that target money, output, nominal income, and the price level. The simulations are not intended to encompass all possible structures of the economy, but instead are meant to suggest how various policies might compare under the assumptions of the model in meeting the social goal of labor-market efficiency.

I. Employment Distortion Under Nominal Wage Contracts

According to the basic neoclassical theory of wage determination, wages tend to be set at a level that reflects both productivity and disutility of work. If the nominal wage is set in advance, it will tend to be set at a level equal to the expected marginal revenue product of labor and the marginal disutility of work. Then, the real wage will be expected, on average, to clear the labor market, and employment will be at optimal levels (leaving aside issues related to monopoly power or other such sources of externalities, which are not essentially monetary problems because there is little the monetary authorities can do to ameliorate them).

Once the nominal wage is set, unanticipated events can render that wage incorrect and cause misallocation. For example, if the demand for commodities rises beyond what was expected at the time contracts were signed, and if monetary policy keeps the money supply constant, the price level will rise, lowering the real wage under contracts. This reduction in the real wage will tend to cause an expansion of employment by profit-maximizing firms. In an extreme case of period-by-period profit-maximization, the expansion of employment would carry to the point at which the marginal product of labor falls to the lower real wage. This expansion of employment is socially inappropriate because the additional employment produces less value of output than the disutility of work it incurs.

To take another example of how predetermined wages can result in inefficiency, consider an autonomous cyclical labor productivity improvement. Further assume, for illustration, that as output supply increases, the price level is kept from falling by monetary expansion. The profit-maximizing firms expand employment in order to take advantage of the higher productivity, but will not face increasing unit labor costs if the contract calls for employees to supply all the labor the firm wants at a predetermined wage. Employment will overexpand because firms are not required to consider the rising disutility of work.

Ideally, real wages should be regulated by policy so that they match the marginal disutility of work. In the case of an autonomous cyclical labor productivity shock, real wages should rise to keep pace with the rise in the disutility of work associated with higher employment. A monetary policy that tended to allow the price level to fall when autonomous increases in labor productivity occur could help real wages match the marginal disutility of work. Then, the employment level would still rise with productivity improvements, but not excessively so. One policy that tends to set up a negative relation between labor productivity shocks and the price level is a nominal income, or GNP, target. In simulations with a model, GNP targets are close to optimal in that people's time tends to be allocated between labor and leisure in an appropriate way.

II. A Simulation Model

The simulation model combines the notion of sticky wages and the IS-LM demand apparatus with autonomous labor productivity shocks. Elsewhere, I have shown that a simpler (constant-velocity) version of the model can account for stylized facts, such as the natural-rate hypothesis and the mild procyclicity of real wages and productivity (see Hoehn [1988]), so long as forward-looking expectations guide nominal wage contractors. The IS-LM apparatus for representing intuitions about demand is preferred here over simple velocity equations, because the effects of monetary policy can be offset or enhanced by changes in velocity, and because IS-LM allows assessment of the information policymakers can obtain from observations on the nominal interest rate. The model has three shocks: to money demand, to commodity demand, and to the marginal labor productivity schedule. These features provide a model consistent with the stylized facts and containing utilitarian welfare criteria for policy.

Relative to the standard macroeconomic models involving wage stickiness, four changes are offered to make a useful policy model.

(i) Expectations of inflation and productivity are forward-looking (Muthian rational).

(ii) Labor productivity is subject to autonomous cyclical variations (as well as to variations induced by shifts in commodity and labor demand).

(iii) Employment is determined not strictly by demand, but is also influenced by supply.

(iv) The information content of the interest rate is used by goods demanders and the central bank.

To incorporate these features, the following model is offered.

Supply Sector

Following Fischer (1977), represent multiyear nominal wage bargaining with two-period staggered, or overlapping, contracts. The model economy is composed of two groups of firms, identical in all respects, except for the date at which currently effective labor contracts were signed. Firms having signed wage contracts at the end of last period ($t-1$) are referred to as group one firms, while those that signed wage contracts at the end of the period before last ($t-2$) are referred to as group two firms. The groups are competitive in that they take the commodity price as given, and contract with workers to pay them their expected marginal revenue product.

Economywide aggregates are simulated by taking the average of the two groups' firms.

The main difference between the determination of wages in the model here and that of other sticky-wage models is that contract wages here adjust completely and efficiently to information available at the time of wage bargains. In some other models, such as that of Taylor (1979), wages can take longer than a contract interval to respond completely to events, and are subject to random variations conceived of as wage-setting errors. Taylor's model can be justified as more realistic. However, the model used here is more consistent with microeconomic theory about the determination of wages and is consistent with the natural-rate hypothesis: the average level of employment is invariant with respect to the money supply rule.

As in most sticky-wage models, variations in employment are those for a representative worker. Implicitly, employment variations are variations in hours worked among workers who each have jobs in all states of the economy. The model falls short of accounting for unemployment.

The determination of employment and wages reflects both Keynesian and neoclassical elements. Hall (1980) and Barro (1977) have sought to reconcile the fact of sticky wages with the neoclassical theory of employment determination by arguing that sticky wages need not have any misallocational effects. Efficient contracts, which could be implemented in the absence of transactions or enforcement costs, would involve optimal employment determination as productivity varied, so that sticky wages would have no allocational effects. Here, it is supposed that there are constraints on optimal contracts that prevent workers and firms from effecting optimal contracts. However, the traditional Keynesian assumption that employment is strictly demand-determined is softened. Instead, the employment reflects both the optimal level (the employment level associated with the intersection of demand and notional supply curves) and the demand for labor at prevailing prices and wages. This is simulated by an equation for employment that makes it a weighted average of both the optimal level and the notional demand. The weight attached to the demand can be conceived of as the degree to which sticky wages have misallocational effects or, alternatively, the degree to which the problems of ideal contract enforcement are effective constraints.

In order to derive this employment equation, first the notional labor demand is developed, then the notional labor supply is formulated, and then they are put together. Finally, the employment equation, in conjunction with the production function and stochastic assumptions about productivity disturbances, implies a supply function, or Phillips Curve: a semireduced form equation for output supply as a function of the state of technology and unexpected inflation.

Notional Labor Demand

A firm's production function is

$$(1) \quad Y_{it} = U_t N_{it}^{\gamma}, \; 0 < \gamma < 1, \; i = 1, 2,$$

where Y_{it} is the output of a firm in group i in period t, N_{it} is the labor input of a firm in group i, and U is a global productivity shock. The marginal product of labor is

$$(2) \quad \frac{dY_{it}}{dN_{it}} = U_t \gamma (N_{it})^{-(1-\gamma)}, \; i = 1, 2.$$

In logarithmic form, output is

$$(3) \quad y_{it} = u_t + \gamma n_{it}, \; i = 1, 2,$$

where the lowercase letters y, u, and n are natural logarithms of their uppercase counterparts. The (log of the) marginal product of labor is

$$(4) \quad ln\left(\frac{dY_{it}}{dN_{it}}\right) = u_t + ln(\gamma) - (1-\gamma) n_{it},$$

$$i = 1, 2.$$

The notional demand for labor by firm i in period t, n_{it}^{d}, is given by the condition that the real wage equals the marginal product of labor:

$$(5) \quad (w_{it} - p_t) = u_t + ln(\gamma) - (1-\gamma) n_{it}^{d},$$

$$i = 1, 2,$$

or

$$(5') \quad n_{it}^{d} = \frac{1}{1-\gamma} [-(w_{it} - p_t) + u_t + ln(\gamma)],$$

where w_{it} is the (log of the) wage received by group i firms' workers in period t, and p is the (log of the) price level.

Notional Labor Supply

The notional supply of labor to a firm is conditioned on the real wage rate:[1]

$$(6) \quad n_{it}^{s} = \beta_0 + \beta_1 (w_{it} - p_t),$$

$$\beta_1 \geq 0, \; i = 1, 2.$$

Determination of Contract Wage

If the labor market cleared each period, fully reflecting the taste and technology conditions underlying notional labor supply and demand, $n^d_{it} = n^s_{it}$, then the employment level at firm i in period t would be

$$(7) \quad n^*_{it} = [\beta_0 + \beta_1 ln(\gamma)]M_0 + \beta_1 M_0 u_t$$

$$\text{where } M_0 \equiv [1+\beta_1(1-\gamma)]^{-1},$$

with n^*_{it} denoting the market-clearing employ. ment level. If wages were not sticky, but varied to clear the market, they would be

$$(8) \quad w^*_{it} = p_t + [ln(\gamma) - (1-\gamma)\beta_0]\, M_0 + M_0 u_t .$$

The contractual wage rate is the expectation of the rate that would clear the labor market. The contract wage for group i is found by taking the expectation of (8) conditioned on information available in period t-i, when the contract was signed.

$$(9) \quad w_{it} = E_{t-i}p_t + [ln(\gamma) - (1-\gamma)\beta_0]\, M_0 + M_0 E_{t-i} u_t,$$

where E_{t-i} is the operator that conditions random variables on realizations at t-i and earlier. Note that, in this formulation, the nominal wage will generally be different in each of the two periods subject to the contract.

Finally, let u_t be a first-order autoregressive process,

$$(10) \quad u_t = \rho_1 u_{t-1} + \epsilon_t,$$

$$0 < \rho_1 < 1, \quad \epsilon_t \sim N(0, \sigma^2_\epsilon).$$

Aggregate Commodity Supply

These elements are sufficient to specify the supply sector of the economy, under the assumption that labor input partly reflects the demand, and partly reflects the optimal level:

$$(11) \quad n_{it} = \phi n^d_{it} + (1-\phi)n^*_{it} .$$

The parameter ϕ represents the degree to which sticky wages cause misallocations, or employment distortions.

Using (3), (5′), (7), (9), (10), and (11), it can be shown that the (log of the) output of group one is

$$(12) \quad y_{1t} = \gamma A + M_2\epsilon_t + M_1\rho_1\epsilon_{t-1} + M_1\rho_1^2 u_{t-2} + G_1(p_t - E_{t-1}p_t),$$

where

$$A \equiv [\beta_0 + \beta_1 ln(\gamma)]M_0$$

$$M_1 \equiv \frac{1-\gamma M_0}{1-\gamma} = (1+\gamma\beta_1 M_0)$$

$$M_2 \equiv \frac{1-\gamma M_0(1-\phi)}{1-\gamma}$$

$$G_1 \equiv \frac{\gamma\phi}{1-\gamma}$$

and the output of group two is

$$(13) \quad y_{2t} = \gamma A + M_2\epsilon_t + M_2\rho_1\epsilon_{t-1} + M_1\rho_1^2 u_{t-2} + G_1(p_t - E_{t-2}p_t).$$

Total output for the economy is taken as the average of y_{1t} and y_{2t}:

$$(14) \quad y_t = \gamma A + M_2\epsilon_t + M_3\rho_1\epsilon_{t-1} + M_1\rho_1^2 u_{t-2} + G_0 \sum_{i=1}^{2} (p_t - E_{t-i}p_t),$$

where

$$M_3 \equiv \frac{2(1-\gamma M_0) + \phi\gamma M_0}{2(1-\gamma)}$$

$$G_0 \equiv \frac{\gamma\phi}{2(1-\gamma)} .$$

Equation (14) provides a characterization of the supply sector of the economy. It shows that output depends on productivity variations and on unanticipated inflation, both with coefficients that depend uniquely on the elasticity of output

■ 1 The notional labor supply schedule could be derived from the primitive utility function:

$$c_0 + c_1 Y_t - c_2 N_t^{c_3}, \; c_1 > 0, \; c_2 > 0, \; c_3 > 1,$$

and the budget constraint:

$$Y_t = (W_t/P_t)N_t$$

The first-order condition on N is:

$$c_1(W_t/P_t) = c_2 c_3 N_t^{(c_3-1)}.$$

Taking the natural logarithm and rearranging it, one obtains the labor supply function:

$$n^s_t = ln[c_1/c_2c_3] + \frac{w_t - p_t}{c_3 - 1}$$

which is the same as equation (6) of the text for $\beta_0 = \ln[c_1/c_2c_3]$ and $\beta_1 = 1/(c_3 - 1)$. (Thanks to Charles Carlstrom for this argument.)

with respect to labor input, y, the elasticity of notional labor supply, β_1, and the degree of misallocation, ϕ. Higher β_1 values increase the responsiveness of output to productivity variations; the responsiveness of output to unanticipated inflation is proportional to ϕ.

Demand Sector

The demand sector of the model is a variant of the familiar IS-LM apparatus, introduced in Hoehn (1987). The main innovation is that goods demanders are allowed to update their inflation expectations in light of the current nominal interest rate and to revise their assessments of the real interest rate accordingly. Much complexity in solutions results from this innovation. The innovation is necessary if the authority's use of the information in the interest rate is to be studied without making the implausible assumption that the authorities know more (specifically, the current interest rate) than do other people. The innovation ensures that any influence monetary policy has over real variables does not arise from superior information.2

The commodity demand function, or IS curve, is

$$(15)\quad y_t^d = b_0 - b_1[R_t - (E^+_{t-1}p_{t+1} - p_t)] + x_t,$$
$$b_1 > 0,$$

$$(16)\quad x_t = \rho_2 x_{t-1} + \lambda_t,$$
$$0 < \rho_2 < 1,\ \lambda_t \sim N(0, \sigma^2_\lambda)$$

where

$$E^+_{t-1}p_{t+1} \equiv E[p_{t+1} | \Omega_t],$$

$$\Omega_t \equiv \text{observable state of economy at time } t$$
$$\equiv \{R_t; S_{t-3},$$

and $S \equiv$ state vector (given a specific identity in the next section). The nominal interest rate, R_t, is measured as the natural logarithm of unity plus the coupon rate of return. The future price expectation, $E^+_{t-1}p_{t+1}$, is conditioned on the observed state of the economy, Ω_t, an information set that includes the current economywide interest rate, R_t, and the lagged state vector, S_{t-1}. $E^+_{t-1}p_{t+1}$ can differ from $E_{t-1}p_{t+1}$ because people use the current nominal interest rate to update their inflation expectations. x_t is a stochastic demand shock.

The money-demand function is conventional:

$$(17)\quad m_t^d - p_t = a_0 - a_1R_t + a_2y_t + v_t,$$

$$(18)\quad v_t = \rho_3 v_{t-1} + \eta_t,$$
$$0 < \rho_3 < 1,\ \eta_t \sim N(0, \sigma^2_\eta),$$

where v_t is the log of the quantity of money and v_t is a first-order autoregressive random disturbance.

Policy Sector

Given the model, a policy rule that is adequate for the policy targets and criteria to be considered, is

$$(19)\quad m_t^s = qR_t + \mu_0 + \mu_1 u_{t-1}$$
$$+ \mu_2 v_{t-1} + \mu_3 x_{t-1} + \mu_4 E_{t-2} u_{t-1}.$$

Harberger Welfare Metric

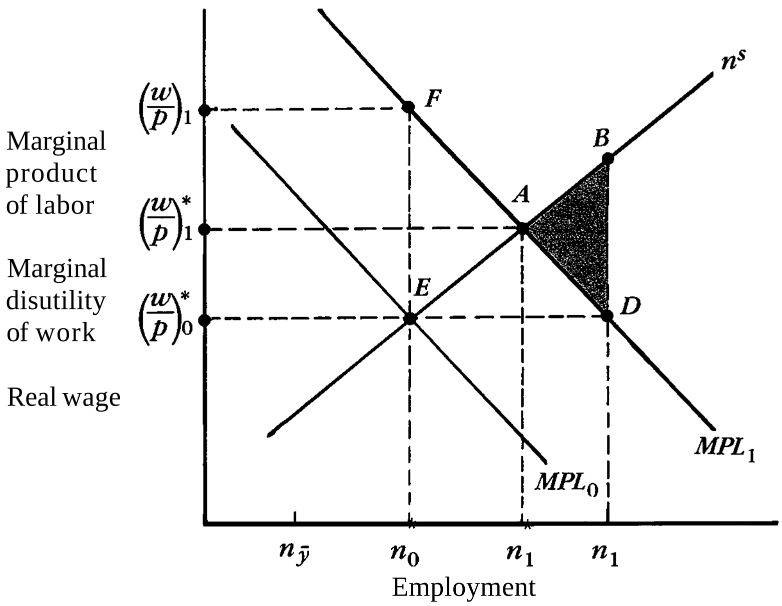
The loss function measures a representative individual's frustration in obtaining an optimal allocation of time between labor and leisure, as productivity and demand conditions change. The method, due to Harberger (1971), of measuring individual frustrations uses the labor supply and demand curves, assuming that they accurately reflect preferences and thereby show how workers and firms would want to adjust output and employment in response to changing productive opportunities. Equilibrium between notional supply and demand is then supposed to be optimal. Equilibrium values of output and employment in this log-linear model are a strict log-linear function of u_t, as shown in equation (7). The welfare loss is taken as proportional to the square of the deviation of the actual from the optimal employment level. This welfare-loss metric is proportional to the area of the familiar Harberger welfare-loss triangles, as shown in the figure of the next section.

In the model with two staggered contracting firm groups, an approximate measure of the expected Harberger welfare loss over the span of a contract is

■ 2 The effect of allowing goods demanders to extract information about inflation from the nominal interest rate was analyzed extensively in Hoehn (1987). It can reverse the usual effects of money supply or demand shocks on the price level and output during the temporary period before shocks become fully known to all. For example, output and prices may temporarily rise in response to an increase in money demand. But such cases arise only in cases of extreme policies, such as crude attempts to smooth interest rates by expanding money greatly in response to a rise in the interest rate, or where structural parameters or relative variances of shocks take on extreme values.

FIGURE 1

Optimal Employment Equates the Marginal Product of Labor With the Marginal Disutility of Work



SOURCE: Author's calculations.

$$\text{(20)} \quad \text{Expected Welfare Loss} = E(n_{1t} - n^*_{1t})^2 + E(n_{2t} - n^*_{2t})^2,$$

where the n_{it} are actual employment levels and the n^*_{it} are the market-clearing employment levels of equation (7). This measure is the sum of the variances of employment from optimal for each of the two periods of any contracting firm, during which it will first be a group-one firm, and then a group-two firm.

III. How Policy Can Minimize Employment Distortions

To understand how a well-chosen policy rule can improve welfare, it is useful to examine the nature of the money-supply responses to various shocks that would fully prevent employment distortions. Such a degree of success is not possible in reality because of policymaker uncertainty about shocks. In the model simulations, it is assumed that the authorities know the structure of the economy, the current interest rate, and the lagged state of the economy; the authorities do not have full information about current shocks. This complicates analysis, motivating a heuristic treatment of the simpler case in which the authorities know the full state and can change the money supply continuously to keep employment for both groups of firms at the ideal level. Readers interested in the final-form solution and the optimal policy rule in the full model may find them available in Hoehn (1989).

The optimal employment level for each group, n^*_0, is determined by the intersection of the marginal product of labor schedule, MPL_0, and the labor supply or marginal disutility of work schedule, n^s, as shown in the figure. This employment level will be chosen by firms only if the real wage is equal to $(w/p)^*_0$. (This statement holds true for any degree of misallocation, ϕ, except zero, in which case nominal wage stickiness cannot create employment distortion. The case illustrated here is the simple case of pure demand-determination of employment, $\phi = 1$. Of course, the size of employment distortions will be smaller if ϕ is a fraction.)

The optimal employment level and the real wage that will induce firms to choose the optimal employment level vary with autonomous labor productivity shocks. For example, a cyclical improvement in labor productivity raises the optimal employment level and the associated real wage. The figure illustrates this with a shift in the marginal product of labor schedule from MPL_0 to MPL_1, which raises the optimal employment level to n^*_1. This optimal level will be chosen by firms if the real wage rises to $(w/p)^*_1$.

The productivity shock case reveals the suboptimality of a price-stabilization policy. Because nominal wages are fixed during the contract interval, stable prices imply that the real wage would remain at the initial level of $(w/p)^*_0$. Firms would choose the employment level n_1, at which the marginal product equals the unchanged real wage. The expansion of employment from n^*_0 to n_1 is an excessive response to the improvement in productivity, because the marginal disutility of work exceeds the marginal product of labor for employment levels above n^*_1. The Harberger welfare loss triangle is BAD.

To prevent firms from overexpansion, the monetary authorities should allow the price level to fall by enough to raise the real wage to $(w/p)^*_1$. Somewhat ironically, this policy will involve an expansion in the money supply. If the money stock were unchanged, the price level would fall too much as output rose. For example, if the velocity of money were constant and the quantity of money were constant, then a productivity improvement would raise the marginal product of labor and—via deflation—raise the real wage by the same amount, to $(w/p)_1$, leaving the profit-maximizing level of employment at n_0^*. The labor market is then at point F in the figure, with welfare loss triangle EFA. The optimal policy response to the productivity shock is to expand the money supply enough to moderate the deflation, so that real wages rise to $(w/p)_1^*$, but no further.

The shift from point E to point F in response to the productivity improvement will always be obtained under a nominal income target, because that shift lowers the price level and raises the output level by the same proportion, leaving their product unchanged. In the simulations with the IS-LM demand apparatus, the velocity of money falls with favorable productivity shocks. Consequently, the nominal income target will necessarily require increases in money to obtain point F. If the increase in money is not forthcoming, as under a constant-money policy, the price level will fall more than one-for-one with the productivity improvement, and the profit-maximizing employment level falls below n_0^*. The welfare loss resulting from sticky wages under a productivity shift is greater under a constant money policy than under the nominal income target, once velocity changes are accounted for.

The optimal policy response to a commodity-demand or money-demand shock is easier to understand than the optimal response to a productivity shock. In the model as specified, such shocks do not alter either the marginal product of labor schedule or the marginal disutility of work. Consequently, the optimal level of employment is unchanged. The optimal policy will attempt to prevent the employment level from changing with demand and money shocks. Employment can be insulated from distortions arising from such shocks by a policy that stabilizes the price level. A stable price level prevents the real wage from changing, preventing firms from desiring a change in employment. Money supply should be decreased with increased commodity demand by an amount adequate to prevent inflation. Money supply should be increased one-for-one with increases in the money-demand function.

A policy of output stabilization is unambiguously worse than a policy of price stabilization. Both of these policies give an appropriate response to commodity-demand and money-demand shocks, but the distortion concurrent with a productivity shock is unambiguously larger under the output stabilization policy. As soon as a single-minded output-stabilizing authority observes a productivity improvement, it will deflate the price level by reducing the money supply. The result is deflation sufficient to drive the real wage above $(w/p)_1$, and employment declines below n_0^*, say to $n_{\bar{y}}$.

The ability of the authority to stabilize output in this example is limited because recontracting firms can offset the real-wage effects of excessive deflation by lowering nominal wages. As soon as one of the groups recontracts, it will reduce wages to aim at an increased employment level, driving the authorities to further reduce employment in the second group via yet more deflation. The second group cannot protect itself against the negative employment distortions by recontracting for lower nominal wages until one more period passes and the old contract expires. The second group's employment must be reduced, if output is to be stabilized, by enough to offset not only the economywide increase in productivity, but must also offset the increase in employment at the recontracting firms, who will rationally anticipate deflation and reduce wages to allow employment to increase to the optimal employment level. Because the loss function is the sum of squared group employment distortions, the concentration of the employment distortion in the second group of firms leads to a sizeable welfare loss.

IV. A Numerical Simulation

In order to illustrate how various policy rules influence employment distortions arising from sticky wages, a simulation can be conducted with particular numerical values for structural parameters. The values chosen for this simulation were the following:

$$(21)\quad \beta_1 = 1/2 \quad \gamma = 1/2 \quad \phi = 1$$
$$a_1 = 2 \quad a_2 = 2/3 \quad b_1 = 1$$
$$\sigma_\epsilon^2 = 1 \quad \sigma_\lambda^2 = 2 \quad \sigma_\eta^2 = 5 \quad \rho_i = 4/5,\ i = 1,2,3.$$

The elasticity of labor supply with respect to the cyclical variations in the real wage was set at one-half, an arbitrary but plausible value. The elasticity of output with respect to labor input, γ, was set at the midpoint of its permissible range, also arbitrary but plausible. The value assigned to the money demand elasticity with respect to the nominal interest rate, a_1, implies, for example, that an increase in the rate from 5 to 6 percent would, for given levels of income and prices, lower real money demand by approximately 1.9 percent. The money-demand elasticity with respect to output, a_2, was set at somewhat less than unity, as suggested by

TABLE 1

Alternative Policy Rules (ϕ = 1)

Policy Parameter[a]	Policy Criterion Money	Output	Price Level	Nominal Income	Optimal
q	0.0	+1.06	−0.05	+0.62	+0.48
μ_1	0.0	−1.97	+3.35	+1.73	+2.06
11.2	0.0	−2.44	−1.56	−2.10	−1.98
μ_3	0.0	+0.80	+0.80	+0.80	+0.80
11.4	0.0	b	−0.84	−0.04	b

a. The money supply rule is $m_t = qR_t + \mu_1 u_{t-1} + \mu_2 x_{t-1} + \mu_3 v_{t-1} + \mu_4 E_{t-2} u_{t-1}$, where u, x, and v are disturbances to goods demand, goods supply, and money demand.
b. The policy parameter μ_4 is irrelevant to the criterion. In simulations, μ_4 is set to zero.
SOURCE: Author's calculations.

TABLE 2

Response of Money to Innovations (ϕ = 1)

Innovation	Policy Criterion Money	Output	Price Level	Nominal Income	Optimal
Productivity					
t	0.0	−0.11	+0.01	−0.06	−0.06
$t-1$	0.0	−2.17	+3.41	+1.25	+1.33
$t-2$	0.0	−1.81	+2.05	+0.98	+1.06
Goods Demand					
t	0.0	+0.25	−0.01	+0.15	+0.12
$t-1$	0.0	−1.60	−1.60	−1.60	−1.60
$t-2$	0.0	−1.28	−1.28	−1.28	−1.28
Money Demand					
t	0.0	+0.31	−0.02	+0.19	+0.15
$t-1$	0.0	+0.80	+0.80	+0.80	+0.80
$t-2$	0.0	+0.64	+0.64	+0.64	+0.64

SOURCE: Author's calculations.

abstract analysis of the transactions demand for money. The commodity-demand elasticity with respect to the real interest rate, b_1, was set to unity because, of all (equally arbitrary) values, unity is the most straightforward choice. (Econometric evidence currently available does not provide direct knowledge of this elasticity.) The relative sizes of the disturbances give considerable scope to demand-side influences on output and employment, and allow for a relatively unstable money-demand function.

In the basic simulation, firms were assumed to choose employment to equate the marginal product of labor with the real wages, so $\phi = 1$. In a second simulation, ϕ was set equal to one-third, in order to see whether the results of the basic simulation were robust with respect to this parameter.

Five different policy rules were simulated, with their response coefficients chosen so as to target *(1)* money, *(2)* output, *(3)* the price level, *(4)* nominal income, or (5) optimal employment. The last of these is, of course, the only optimal policy by the criterion employed, but it is instructive to compare results of other potential targets.

The policy rules' response coefficients, q and the μ_i, are displayed in table *1*. The final-form solution for the money supply is determined by both these coefficients and the solution for the nominal interest rate (because of the qR_t term in the money supply rule), and is shown in table *2*

TABLE 3

Welfare Losses Under Alternative Policies ($\phi = 1$)

Loss due to shocks to:	Policy Criterion				
	Money	Output	Price Level	Nominal Income	Optimal
Productivity	2.86	14.99	1.80	0.38	0.19
Goods demand	6.91	3.04	1.96	2.47	2.35
Money demand	4.52	0.24	1.28	0.66	0.76
TOTAL LOSS	14.29	18.27	5.04	3.51	3.30

SOURCE: Author's calculations.

for each of the five alternative policies. In the immediate period of impact, the monetary authority's response to a shock is equal to q , its interest rate response coefficient, times the response of the interest rate to the shock. For example, under a policy of stabilizing output, the money supply is increased 1.06 for each one-point change in the interest rate. A productivity shock in period t reduces the interest rate by –0.10 (not shown in tables) under this policy rule, so the response of money at time t to a productivity shock in period t is 1.06 times –0.10, or about –0.11.

Only after one period has passed can the monetary authority observe all three shocks independently and tailor its response to each one separately. For example, the output-stabilizing policy contracts the money supply by 2.17 at time t for a one-unit innovation to productivity in the previous period, ϵ_{t-1}. This response reflects two channels: first, an indirect channel involving the change in the interest rate, –0.19, times the response coefficient q = 1.06, or about –0.20. To this is added the direct response coefficient on $t-1$ productivity, $\mu_1 = -1.97$. Together, these add to –2.17, the total contraction of the money supply required to prevent period-t output from responding to period $t-1$ productivity innovations. A similar calculation involving direct and indirect effects finds that the output-stabilizing policy contracts the money supply at time t by 1.81 in response to a unit productivity innovation in period t – 2.

Aside from the constant-money policy, the policies considered are identical in their money-supply responses to goods demand or money demand shocks, once these shocks are observed. In this model, all the activist targets are essentially equivalent in terms of the implied response of the money supply to these demand-side shocks.

The main difference among the active money-supply policies lies in the response of money to productivity shocks. The output-stabilizing policy's response is too restrictive; it contracts money at time t by 2.17 after a unit productivity innovation in period t – 1, contrasting with an optimal increase of 1.33. The price-stabilization rule responds too expansively; it expands the money supply by 3.41. The nominal income target's response is to expand the money supply by 1.25, very close to optimal. These differences among alternative active policies in their response to productivity shocks account for the relative rankings of their efficiency.

Expected welfare losses under alternative policies, shown in table 3, are the sum of the mean squared deviations of group one and group two employment levels from optimal employment levels. Given the information constraint the authority faces, it can reduce this loss measure to 3.30 using the optimal policy. Most of this loss, 2.35, is attributable to goods-demand shocks occurring in the current period; a small fraction is attributable to productivity shocks occurring in the current period. Distortions due to shocks in period $t-1$ can be completely eliminated by policy responses, while distortions due to t – 2 or earlier shocks are eliminated by wage recontracting by both groups of firms.

The nominal income targeting policy is close to optimal; its welfare loss is 3.51, only slightly higher than for the optimal policy. The output-stabilizing policy is far worse, with a total expected loss of 18.27, most of which is due to productivity shocks. The constant-money policy is not much better than the output-stabilizing policy; it generates substantial employment distortions in the face of goods-demand and money-demand shocks, which the activist policies make active efforts to prevent. Finally, the price-stabilization policy results in somewhat greater losses than the nominal income policy, but results in much smaller losses than the output or money targeting policies.

TABLE 4

[illegible]

Innovation	Money	Output	Price Level	Nominal Income	Optimal
	Policy Criterion				
Productivity					
t	–0.28	–0.34	–0.28	–0.32	–0.30
$t-1$	–1.64	–3.84	+1.28	–0.42	0.0
$t-2$	0.0	0.0	0.0	0.0	0.0
Goods Demand					
t	+0.70	+0.88	+0.70	+0.78	+0.76
$t-1$	+1.58	0.0	0.0	0.0	0.0
$t-2$	0.0	0.0	0.0	0.0	0.0
Money Demand					
t	–0.38	–0.16	–0.36	–0.26	–0.28
$t-1$	–0.80	0.0	0.0	0.0	0.0
$t-2$	0.0	0.0	0.0	0.0	0.0

SOURCE: Author's calculations.

TABLE 5

[illegible]

Loss due to shocks to:	Money	Output	Price Level	Nominal Income	Optimal
	Policy Criterion				
Productivity	0.51	1.03	0.21	0.05	0.04
Goods demand	1.37	0.60	0.44	0.54	0.54
Money demand	0.83	0.14	0.32	0.22	0.22
TOTAL LOSS	2.72	1.78	0.98	0.80	0.79

SOURCE: Author's calculations.

The deviations of employment from optimal for the two groups can be read from table 4. The table lists the deviations for the second group; the deviations for the first group, $(n_{1t} - n^*_{1t})$, are the same as for the second group for period-t shocks, but recontracting by this group makes the period-t employment distortion equal to zero for $t-1$ or earlier shocks. A one-unit innovation in productivity at time t raises the optimal employment level for both groups by 0.40 in time t. Given that the effect of an innovation on the marginal productivity schedule decays at the rate $\rho_1 = .8$, optimal employment increases by 0.32 and by about 0.26 in response to unit productivity innovations in periods $t-1$ and $t-2$.

The gross suboptimality of the output-stabilizing policy reflects the employment distortion in the second, nonrecontracting, group, in response to a productivity innovation in period $t-1$. Because policy responds by contracting the money supply, generating deflation and an excessive rise in the real wage for the nonrecontracting group, employment for that group falls by 3.52, in sharp contrast with the increase of 0.32 in optimal employment. The distortion is then –3.84. In order to keep output fixed, the authorities must reduce employment in the second group, and this reduction must be enough to offset both the economywide productivity improvement and the rise in employment by 0.32 in the first, recontracting, group.

The GNP targeting policy is very close to

TABLE 6

Relation Between Money and Output Under Alternative Policies (ϕ = 1)

Covariation due to shocks to:	Policy Criterion				
	Money	Output	Price Level	Nominal Income	Optimal
Productivity	0.0	–1.51	+8.76	+3.10	+3.48
Goods demand	0.0	+0.22	–0.01	+0.12	+0.09
Money demand	0.0	–1.95	+0.02	–0.12	–0.11
CORRELATION	—	–0.30	+0.59	+0.30	+0.34

SOURCE: Author's calculations.

optimal. It handles money-demand and commodity-demand variations appropriately, and generates a mild and nearly optimal deflation in response to productivity improvements. The degree of closeness to optimality depends on various parameters, but is not, it appears, sensitive to the degree to which sticky wages cause misallocations, ϕ , at least at the chosen values of the other structural parameters. Table 5 shows the welfare losses in the model for $\phi = 1/3$.

The output targeting policy is generally the worse in terms of employment distortion (except when $\phi = 1/3$, when the constant-money policy is worse). The output targeting policy generates the greatest losses when productivity shocks occur. Output targets handle commodity- and money-demand shocks, however, in an appropriate manner.

The price-stabilization policy results in over-employment when a productivity improvement occurs. The policy is too stimulative; it does not provide for the deflation required to raise the real wage in line with marginal productivity at the new optimal employment level. In the case of commodity- and money-demand shocks, however, a policy of price stabilization provides essentially the same optimal response as does the nominal and real GNP targets.

The constant-money policy accrues losses in the case of all kinds of shocks. The loss attending productivity shocks is less than in the case of the output target, but the money-targeting policy fails to respond appropriately to commodity- or money-demand shocks. In the simulation, the constant-money policy results in less employment distortion than the output-stabilizing policy, unless the degree of misallocation is small, such as $\phi = 1/3$.

V. Conclusion

A monetary policy that seeks to aid wage contractors in avoiding employment distortions due to sticky wages will attempt to keep the real wage equal to the marginal disutility of labor in all states of the economy. Such a policy will require money supply expansion when cyclical improvements in labor productivity occur. To the extent that productivity variations are an important factor in the business cycle, the optimal money supply rule will involve a positive correlation between money and output. (See table 6.) Hence, the belief, common among economists, that sticky-wage models argue for a countercyclical or output-stabilizing policy is not necessarily correct, once productivity shocks are taken account of.

In simulations, it was found that a nominal income target might be reasonably close to the optimal policy. This result is useful because the Federal Reserve may not be able to predict and target optimal employment levels because of uncertainty about the structural parameters and shock variances needed in a welfare analysis, yet can probably predict and target nominal income using its models and judgmental forecasters. After all, the main objective of macroeconometric models has been the prediction and potential control of national income. The analysis of this paper tends to give additional justification to proposals for nominal income targeting, including those by Meade (1978), Tobin (1980), Hall (1983), Gordon (1985), and McCallum (1987).

The relative near-optimality of a nominal income target might not be robust to all conceivable values of the labor market parameters, y and β„ however. For example, if the marginal product of labor curve declines steeply (γ close to zero), and/or if the notional labor supply curve is nearly horizontal (β_1 very large), then a price target will do as well or better than a nominal income target. More precisely, if $M_0 = [1 + \beta_1(1 - y)]^{-1}$ is close to unity, then a nominal income target will be close to optimal, but if M_0 is close to zero, then a price level target will be close to optimal.3 In the simulation, y = 1/2 and $\beta_1 = 1/2$, so $M_0 = .8$, which is rather close to unity. In order to adequately confirm the relative efficiency of a nominal income target relative to a price target, econometric evidence and a sensitivity analysis are needed to rule out small values of M_0. In general, the optimal policy response to a productivity improvement will be one that is less stimulative than that implied by a price target and more stimulative than that implied by a nominal income target.

If the specification of the model were modified to allow for costs of changing commodity prices ("menu costs"), or to allow for some degree of commodity price stickiness, then a price-targeting policy might yet be better than a nominal income target. Many other elements of more detailed macroeconometric models have unknown implications for the welfare analysis. Much more research along these lines is needed for an adequate welfare analysis of monetary policy toward the business cycle.

Glossary of Variables and Parameters

Endogenous Variables

y	output
y_1	output of group 1 firms
y_2	output of group 2 firms
p	price level
R	nominal interest rate
m	money stock
w	wage rate
w^*	market-clearing wage rate
n	employment
n_1	employment of group 1 firms
n_2	employment of group 2 firms
n^*	optimal employment level

Exogenous Variables

ϵ	innovation to the productivity disturbance, u
λ	innovation to the commodity-demand disturbance, x
η	innovation to the money-demand disturbance, v

Slate Vector

$$S_t \equiv \{\epsilon_t, u_{t-1}, E_{t-2}u_{t-1}; \lambda_t, x_{t-1}, E_{t-2}x_{t-1}; \eta_t, v_{t-1}, E_{t-2}v_{t-1}\}$$

Information Set, or Observed Slate

$$\Omega_t \equiv \{R_t; u_{t-1}, E_{t-2}u_{t-1}; x_{t-1}, E_{t-2}x_{t-1}; v_{t-1}, E_{t-2}v_{t-1}\}$$

Parameters

All nonpolicy parameters are nonnegative.

a_1 =	elasticity of money demand with respect to interest rate = $dln(M/P)/dln(1 + R)$
a_2 =	elasticity of money demand with respect to output
b_1 =	elasticity of aggregate demand with respect to real interest rate
β_1 =	elasticity of notional labor supply with respect to real wage
y =	elasticity of output with respect to labor input
q =	coefficient of money-supply response to interest rate
μ_i =	coefficients of money-supply response to lagged state variables (see equation 19 of the text)
σ_ϵ^2 =	variance of productivity innovation
σ_λ^2 =	variance of commodity-demand innovation
σ_η^2 =	variance of money-demand innovation

3 Bean (1983) apparently was the first to note this.

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