International Finance Discussion Papers

Number 161

March, 1979

STABILITY IN FINANCIAL AND LABOR MARKETS: IS THERE A TRADEOFF?

by

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Does the FED have to choose between stability in financial markets and stability in labor markets? Some recent econometric simulations would seem to suggest that it does.[1] The very existence of such a tradeoff implies that policy making is more than a technical exercise. It is a political process; one constituency is hurt by instability in financial markets, while a largely different constituency is hurt by instability in labor markets.

There is probably no reason to believe that the FED consciously favors one constituency over the other;[2] however, there is some reason to think that interest rate stability ranks high among its priorities. The "real bills" doctrine, which was a part of the original act establishing the Federal Reserve System, called for a policy that would set interest rates "with a view of accommodating commerce and business" without encouraging wasteful or "speculative" ventures.[3] More recently, there has been much discussion of the use of interest rates as "intermediate" targets of monetary policy, and indeed we have witnessed a variety of policy regimes which might be characterized by the degree of flexibility in the rate of interest.

Most existing macroeconometric policy models are not well suited to investigate these matters. Typically, they do not explain what is wrong with instability in financial and labor markets. They do not

* I would like to thank Jo Anna Gray and Dale Henderson for useful discussions of the material presented here; however the views expressed here are solely those of the author and do not necessarily represent the views of the Federal Reserve Board or other members of the staff.

explain who is being hurt or how, and they do not incorporate private sector reactions to a change in stability.[4] Consequently, these models do not imply operational measures of stability in the two markets, and they are not likely to give accurate descriptions of policy tradeoffs. Indeed, there may not even be a tradeoff if stability is appropriately defined and if private sector responses to changes in stability are adequately taken into account.

The purpose of this paper is to examine various specifications of a model in which stability matters to market participants and in which private sector behavior in response to changes in stability is modeled explicitly. It will be seen that in some cases there is a tradeoff for monetary policy, while in others there is not.

Indexing is one way in which labor market participants can insulate themselves from unforseen fluctuations in the general price level. The paper presents a new way of modeling wage indexation schemes in a dynamic setting. It will be seen that successful wage indexation may have the effect of destabilizing financial markets.

Finally, the paper will illustrate the game-theoretic nature of policy models incorporating "rational" expectation formation.[5] When there is a tradeoff and if the FED chooses to stablilize financial markets, then the selection of monetary policy rules and wage indexation schemes may be viewed as a non-cooperative game. This game can be quite explosive in the sense that Nash-Courmot solutions do not exist.

I. THE MODEL:

The model will be presented in three stages. First, labor markets and wage indexation will be described, and an output supply curve will be derived. Then in part B, aggregate demand will be specified, and finally in part C, the financial sector and monetary policy will be described.

A. Labor Markets and Wage Indexation:

The supply side of the economy is characterized by competitive firms and wage setting labor contracts. Nominal wage rates are quoted for a specified length of time in a labor contract; there may be an "escalator clause" which calls for a periodic adjustment of future wage rates in response to observed movements in a price index. Firms are free to hire any amount of labor they choose at the wage rate specified in the labor contract; they are assumed to maximize profits period by period.[6]

The typical firm is assumed to have a log-linear production function

$$y_t^i = \beta_o + \beta_1 n_t^i \qquad 0 < \beta_1 < 1 \tag{1}$$

where y_t^i is the log of output produced in period t and n_t^i is the log of labor employed in period t. The firm takes prices from the market and wages from the labor contract and hires labor up to the point where the cost of a marginal unit just offsets its product; that is

$$w_t^i - p_t = \beta_2 - (1 - \beta_1)\, n_t^i \tag{2}$$

where w_t^i is the log of the nominal wage rate and p_t is the log of the price of output.

How are nominal wage rates set when the contract is negotiated? Notice that equation (2) represents a real wage-employment tradeoff for the workers at this firm. It is assumed that the firm and its workers have agreed upon a real wage target α which represents their real wage-employment preference for the time period spanned by the labor contract. From (2) then,

$$\bar{n}^i = (\beta_2 - \alpha)/(1 - \beta_1)$$

is the preferred rate of employment; it will be called the "natural" rate of employment. Since contracts are written in nominal terms, future price levels must be predicted and nominal wage rates set accordingly. In fact, the wage setting problem can be reformulated as a price prediction problem. Let

$$z_t^i = \alpha - (w_t^i - p_t)$$

The prices that will obtain during the contract period are of course unknown at the time the contract is written, but the goal is to specify a set of nominal wage rates that will in some sense minimize the real wage errors. Let p_t^e be a prediction of the price that will obtain in period t and suppose the nominal wage for period t is set so as to make the expected real wage equal to α, then $w_t - p_t^e = \alpha$ and

$$z_t^i = \alpha - [(\alpha + p_t^e) - p_t] = p_t - p_t^e \tag{3}$$

Specifying nominal wage rates that will minimize real wage errors is equivalent to choosing price predictions that will minimize price prediction errors; the goal from either point of view is to make the z_t^i "small."

Equations (1), (2) and (3) may be solved for real wages, employment and output in terms of the price prediction errors:

$$w_t^i - p_t = \alpha - z_t^i \tag{4}$$

$$n_t^i = \bar{n}^i + \gamma z_t^i \qquad \bar{n}^i = (\beta_2 - \alpha)/(1 - \beta_1) \qquad \gamma > 0 \tag{5}$$

$$y_t^i = \bar{y}^i + \phi z_t^i \qquad \bar{y}^i = \beta_o + \beta_1 \bar{n}^i \qquad \phi > 0 \tag{6}$$

The "natural" rates $\bar{n}^i$ and $\bar{y}^i$ are the preferred rates of employment and output implied by the choice of α as a real wage target. Price prediction errors cause deviations in employment and output about their "natural" rates, and in this model, minimizing price prediction errors is equivalent to stabilizing employment and output about their "natural" rates.[7]

All that remains is to explain how the price predictions are made. If the firm and its workers' loss for z_t^i can be represented by a convex (but not necessarily symmetric) function, and if p_t is viewed as a normally distributed random variable, then the price prediction that minimizes the expected loss in period t is[8]

$$p_t^e = E[p_t | I]$$

where $E[\cdot]$ is the mathematical expectations operator and I is the information set used in making the prediction. (The composition of the information set I is determined by the type of indexing scheme that is chosen; more on this later.) The model developed in this paper will be (log) linear with normally distributed disturbance terms; so p_t will indeed be distributed normally. Furthermore, it will be assumed that market participants' know the probability distributions of the random variables;[9] p_t is viewed as being normally distributed and p_t^e is the model's own expected value of p_t, conditional on information set I.

Now suppose that the contract does not include any indexing scheme. The information set I includes only the information available at the time the contract is negotiated. Let D_τ represent the set of data available at the end of period τ; it includes observations on all variables dated τ or earlier. And let $p_{t|\tau} \equiv E\,[p_t|D_\tau]$. If the contract is negotiated at the end of period t_o, then $p_t^e = p_{t|t_o}$ and $z_t^i = p_t - p_{t|t_o}$.

There is already a rather large literature associated with the type of model outlined above.[10] The length of labor contracts figures prominately in this literature. If contracts span two or more periods and if disturbance terms are serially correlated, then monetary policy can play a stabilization role in labor markets. If, on the other hand, contracts are renegotiated each period, then the results of Sargent and Wallace (1975) obtain. In what follows, it will be assumed that labor contracts span two or more periods. This would seem to be the relevant case. In the United States, labor contracts typically span one to three year periods while the FED makes monetary policy on a monthly (or quarterly) basis. Presumably the costs of renegotiating on a monthly (or quarterly) basis outweigh the benefits (in terms of more accurate price predictions).[11]

Now consider various indexing schemes that might be written into the labor contract. As the firm and its workers progress through the periods covered by the contract, new data on prices, productivity, interest rates, etc. will become available, though presumably at some some cost. An indexing scheme is an explicit formula for adjusting the remaining wage rates in the contract on the basis of new data as it becomes available. In terms of the framework developed above, the information set I is expanded to include new data, modifying the price predictions and the nominal wage settings for the rest of the contract. Which new data is included? Presumably, this too is determined by weighing the costs and benefits of more complicated schemes.[12]

The indexing scheme postulated in this paper will be in the nature of a "cost of living" clause. When a contract is negotiated, price predictions are made for each period covered by the contract and nominal wage rates are quoted in the contract. However, the contract also specifies a rule for making periodic adjustments in the remaining wage rates based upon observed movements in the price level. More specifically, the initial price prediction for period t is $p_{t|t_o} = E\ [p_t | D_{t_o}]$, but the information set for the prediction p_t^e (which is used in the final setting of w_t) is

$$I = D_{t_o} \cup \{p_{t_o+1}, \ldots, p_{t-1}\}$$

and it can be shown that

$$p_t^e = E\,[p_t | I] = p_{t|t_o} + \theta_1\, \hat{p}_{t-1|t_o} + \ldots + \theta_{t-1}\, \hat{p}_{t_o+1|t_o}$$

where the $\hat{p}_{t-j|t_o} \equiv p_{t-j} - p_{t-j|t_o}$ are the price prediction errors based upon the original predictions and the coefficients θ_j depend upon the variances and covariances of the original price prediction errors.

In what follows, it will be assumed that all labor contracts cover two periods. While this assumption is not very realistic, it does simplify matters mathematically and the resulting model will be sufficiently rich for present purposes. If period t is the first period of the contract, then the contract was negotiated in period t-1 and

$$p_t^e = p_{t|t-1} \quad \text{and} \quad z^i_{t|t-1} = \hat{p}_{t|t-1} \tag{7}$$

If period t is the second period, then

$$p_t^e = p_{t|t-2} + \theta \hat{p}_{t-1|t-2} \quad \text{and} \quad z_t^i = \hat{p}_{t|t-2} - \theta \hat{p}_{t-1|t-1} \tag{8}$$

where

$$\theta = \text{cov}\,(\hat{p}_{t|t-2}, \hat{p}_{t-1|t-2})/(\text{var}\,(\hat{p}_{t-1|t-2}) \tag{9}$$

If $\hat{p}_{t-1|t-2}$ and $\hat{p}_{t|t-2}$ are correlated, then the prediction error made in the first period contains information that can be used to improve performance in the second period;[13] θ is a markup factor specifying how this information is to be used. Serially correlated disturbances to the economy will cause the original price prediction errors to be correlated (as will other types of "lagged" effects), and a counter cyclical monetary policy can modify the correlation structure. To choose the proper θ, the writers of labor contracts must not only know the correlation structure of the disturbances, but also the policy rule governing monetary policy.[14]

The procedure in the present paper will be to leave θ as an unspecified parameter until a reduced form for the price prediction error has been derived; then θ will be chosen to minimize the variance of the price prediction error in the second period of the contract. Notice that the contract writers' loss function is now assumed to be quadratic (and thus symmetric). This stronger assumption about preferences will facilitate the analysis to follow, but it was not needed in the discussion above.

The next step is to derive an aggregate supply function. Suppose there are N identical firms, each with two period labor contracts. And suppose that the contracts are staggered; one half of the firms are negotiating new contracts at the end of each period. The aggregate supply function will be of the form

$$y_t = \bar{y} + s\, z_t \tag{10}$$

where

$$z_t = \hat{p}_{t|t-1} + (\hat{p}_{t|t-2} - \theta \hat{p}_{t-1|t-2}) \tag{11}$$

and y_t is the log of aggregate output, $\bar{y}$ is the log of the aggregate "natural" rate of output, and s is a positive constant. The first term in z_t is for the firms in the first period of their labor contract, the second term is for the firms in the second period of their contract. There will be an analogous equation for aggregate employment

$$n_t = \bar{n} + \ell z_t \qquad \ell > 0 \tag{12}$$

and the "average" real wage will be

$$\begin{aligned} w_t - p_t &= (1/2)(\alpha - \hat{p}_{t|t-1}) + (1/2)(\alpha - \hat{p}_{t|t-2} - \theta \hat{p}_{t-1|t-2}) \qquad (13) \\ &= \alpha - (1/2)z_t \end{aligned}$$

Note that the θ that minimizes the variance of the price prediction error in the second period of the labor contracts is also the θ that minimizes the variance of z_t. Indexing of this form stabilizes employment and output about their "natural" rates, as well as real wages about α.

B. Aggregate Demand for Output:

Aggregate demand is given a log-linear specification

$$y_t = \bar{y} - d\,(r_t - \pi) + U_t \qquad d > 0 \tag{14}$$

where r_t is the interest rate, π is the (asymptotic) expected rate of inflation,[15] and U_t is a normally distributed random variable.

The real rate of interest, $r_t - \pi$, is assumed to effect private comsumption demand; the capital stock and investment have been suppressed in the present model (though they could have been incorporated in the manner described by Canzoneri (1980)).

C. The Asset Sector and Monetary Policy:

There are two assets, money and bonds. Money earns a certain nominal rate of return, zero. Bonds earn a random nominal rate of return, r_t. Money balances are held for transactions purposes and for speculative purposes. Speculative demand is provided by risk averse portfolio managers seeking to maximize expected utility of wealth. Since r_t is a normally distributed random variable, their expected utility and their asset demands can be expressed in terms of means and variances. The demand for real money balances will also be given a log-linear specification:

$$m_t - p_t = \gamma + V_{1,t} \qquad \gamma \equiv m_o + m_1\bar{y} - m_2\bar{r} + m_3\sigma_r \tag{15}$$

where $\bar{r}$ and σ_r^2 are the steady state mean and variance of r_t, $V_{1,t}$ is a normally distributed random variable, and m_t is the log of the nominal stock of money. A countercyclical policy that reduced σ_r^2 would make portfolio managers better off (ex ante).

The FED controls the level of reserves in the banking system via open market operations. The banking system multiplies up this stock of reserves (by a factor depending upon the interest rate) to form the money stock. So the nominal money supply is

$$m_t = h_t + mr_t + V_{2,t} \qquad m > 0 \tag{16}$$

where h_t is the log of the stock of reserves and $V_{2,t}$ is a normally distributed random variable. The FED will be assumed to use a feedback rule to set h_t each period; this will be discussed in the next section. Summarizing, equilibrium in the financial sector is implied by

$$h_t - p_t + mr_t = \gamma + V_t \qquad V_t = V_{1,t} - V_{2,t} \tag{17}$$

Before going on, it should be noted that money demand could have been specified in a variety of ways. Perhaps a more natural specification would postulate conditional means and variances; that is, $\bar{r}$ and σ_r^2 might be replaced by $r_{t|t-1}$ and $r^2_{t|t-1} \equiv E[(r_t - r_{t|t-1})^2|D_{t-1}]$. Portfolio managers would be better off if $r^2_{t|t-1}$ were reduced, but the interested reader will be able to show that monetary policy rules and wage indexing schemes do not effect this conditional variance. They play no stabilization role in financial markets under this specification. There would be no tradeoff of the type described in the introduction.

Alternatively, a theory analogous to the long-term labor contracts could be worked out for portfolio managers. It may not be worthwhile for all portfolio managers to monitor data continuously and make portfolio decisions each period. Thus a succession of staggered long-term portfolios could be postulated involving terms like $r^2_{t|t-1}$ and $r^2_{t|t-2}$. The interested reader will be able to show that policy rules and wage indexing schemes do play a stabilization role under this specification; that is, they effect $r^2_{t|t-2}$.[16]

II. ANALYSIS OF THE MODEL

Once the stochastic processes generating disturbance terms are specified, and once θ and the feedback rule governing monetary are fixed, the model outlined above will generate equilibrium time paths for price, output, employment, real wages and the rate of interest. In this section, the behavior of the model will be examined under various specifications of the disturbance structure and under various assumptions about the goals of monetary policy.

First, reduced forms will be derived for price, output and the rate of interest. These reduced forms will be quite general in the sense that they assume very little about the structure of disturbance terms, monetary policy, or the value of θ. Specific examples will follow.

A. Reduced Forms for Price, Output and the Rate of Interest:

The supply and demand equations, (10) and (14), and the financial markets' equilibrium condition, (17), can be solved for y_t, p_t and r_t in terms of z_t:

$$y_t = \bar{y} + s\ z_t \tag{18a}$$

$$p_t = (m\ \pi - \gamma) - (ms/d)\ z_t + x_t \tag{18b}$$

$$x_t \equiv h_t + (m/d)\ U_t - V_t$$

$$r_t = \pi - (s/d)\ z_t + (1/d)\ U_t \tag{18c}$$

All that remains is to find a reduced form for z_t. The derivation of this reduced form is straightforward, but tedious; it is therefor relegated to an appendix. It turns out that

$$z_t = ab\ \hat{x}_{t|t-1} + b[\hat{x}_{t|t-2} - a\theta\ \hat{x}_{t-1|t-2}] \tag{18d}$$

where

$$0 < a = d(d + 2ms)^{-1} < b = d(d + ms)^{-1} < 1$$

B. <u>Example</u> 1: Serially Correlated Demand Disturbances

In this first example, it is assumed that aggregate demand disturbances are serially correlated and monetary disturbances are negligible; that is, $V_t = 0$ and

$$U_t = \rho U_{t-1} + u_t \qquad \rho > 0 \tag{19}$$

where $u_t \sim N(o,\sigma_u^2)$ and $E\ (u_t u_s) = 0$ for $s \neq t$. Monetary policy is governed by a rule

$$h_t = \bar{h} - hU_{t-1} \tag{20}$$

where the feed back term, hU_{t-1}, represents the countercyclical component of monetary policy.[17]

Using the reduced forms (18), it can be shown that

$$x_t = \bar{h} + (m/d)u_t + [(m/d)\rho - h]\ u_{t-1} + \rho[(m/d)\rho - h]\ U_{t-2} \tag{21a}$$

$$y_t = \bar{y} + s\, z_t \qquad n_t = \bar{n} + \ell\, z_t \qquad w_t - p_t = \alpha + (1/2)z_t \quad (21b)$$

$$z_t = c_1 u_t + b(m/d)[\rho - (d/m)h - a\theta]\, u_{t-1}$$

$$r_t = \pi + c_2 u_t + (b/d)[\rho + sh + s(m/d)a\theta]u_{t-1} + (\rho^2/d)U_{t-2} \quad (21c)$$

where c_1 and c_2 are constants.

Suppose there were no countercyclical monetary policy or wage indexation; that is, suppose $h = 0 = \theta$. In this case, z_t would be serially correlated, and employment and output would "cycle" about their "natural" rates. The amplitude of this cycling can be measured by the (asymptotic) variance of z_t.

$$\sigma_z^2 = \{c_1^2 + b^2(m/d)^2[\rho - (d/m)h - \theta a]^2\}\sigma_u^2$$

Well designed monetary policies and indexing schemes can reduce the amplitude of the cycling by offsetting the lagged or cyclical component of z_t; in fact, any combination of h and θ satisfying

$$\rho - (d/m)h - \theta a = 0$$

will completely eliminate the cyclical component and reduce the variance of z_t to $c_1^2\sigma_u^2$. Note that vigouous efforts on the part of the monetary authorities should be accompanied by little or no indexing in labor contracts. A good countercyclical monetary policy will take the correlation out of the price prediction errors in (9), and θ should be small or zero. Similarly, a well designed indexing scheme reduces the need for countercyclical monetary policy.

Minimizing the variance of z_t is clearly the goal of each firm and its workers; as noted earlier, this minimizes the variance of price prediction error, and thus the variances of real wages and employment about their preferred values. If the goal of monetary policy is also to stabilize labor markets, then the only problem would appear to be one of coordination; the monetary authority must somehow coordinate its choice of a countercyclical policy (h) with the private sector's choice of an indexing scheme (θ) so as to produce a desirable result. Any combination of h and θ satisfying

$$\rho - (d/m)h - a\theta = 0$$

will completely eliminate the cyclical component of z_t, and positive values of h and θ such that

$$2\rho - (d/m)h - a\theta > 0$$

(the shaded area in figure 1) will at least make the variance of z_t smaller than it would be in the absence of such policies. However, the settings $h = (3/2)(m/d)\rho$ and $\theta = (3/2)\rho/a$ (point A in figure 1), either of which would be stabilizing in the absence of the other, combine to destabilize labor markets. Uncoordinated attempts to stabilize real wages or employment may lead to overly vigorous efforts, efforts that might even combine to destabilize labor markets.

Perhaps of more importance though is the tradeoff problem discussed in the introduction. Monetary policies and indexing schemes that stabilize labor markets tend to destabilize financial markets; positive values of h and θ increase the (asymptotic) variance of r_t, making the risk averse portfolio managers worse off. Minimizing the variance of z_t is, of course, the goal of indexing; that is what makes the firm and its workers well off. If the monetary authority has portfolio managers' ex ante interests in mind or if it is keying on the interest rate as an intermediate target, then minimizing σ_r^2 will be the goal of monetary policy. Goals are conflicting, and the setting of h and θ might be thought of as a non-cooperative game.

It turns out that this is a very explosive game. If the indexing parameter is set at θ, the monetary authority minimizes σ_r^2 by setting h according to the rule

$$h = -(ma/d)\theta - \rho/s \quad .$$

If the monetary policy parameter is set at h, the firm and its workers minimize the variance of z_t by setting θ according to the rule

$$\theta = -(d/ma)h + \rho/a \ .$$

These reaction functions are graphed in figure 2. They are parallel lines; there is no Nash solution. It is difficult to speculate what the outcome of such a situation would be.[18]

C. <u>Example 2</u>: Serially Correlated Monetary Disturbances.

Here monetary disturbances are substituted for demand disturbances; $U_t = 0$ and

$$V_t = \rho V_{t-1} + v_t \qquad \rho > 0 \tag{22}$$

where $v_t \sim N(0,\sigma_v^2)$ and $E(v_t v_s) = 0$ for $t \neq s$. Monetary policy is governed by[19]

$$h_t = \bar{h} + h\, V_{t-1} \tag{23}$$

and in this case, (18) implies

$$x_t = c_7 - v_t + (h - \rho)v_{t-1} + \rho(h - \rho)V_{t-2} \tag{24a}$$

$$y_t = \bar{y} + s\ z_t \qquad n_t = \bar{n} + \ell z_t \qquad w_t - p_t = \alpha + (1/2)z_t \tag{24b}$$

$$z_t = c_8 v_t - b(\rho - h - a\theta)v_{t-1}$$

$$r_t = c_9 - (s/d_1)z_t \tag{24c}$$

where c_7, c_8 and c_9 are constants.

With monetary disturbances there is no tradeoff between stability in labor markets and stability in financial markets; minimizing the variance of z_t is equivalent to minimizing the variance of r_t. Any combination of h and θ satisfying $\rho = h + a\theta$ will completely eliminate the cyclical components in z_t and r_t. Of course, there remains the problem of coordination, so that the combined stabilization effort will not be too vigorous.

Monetary policy and indexing appear to be perfect substitutes in the face of monetary shocks. The reduced form for the price level takes the form

$$p_t = c_{10} - c_{11}\ z_t + x_t$$

where c_{10} and c_{11} are constants. The interested reader will be able to show that a monetary policy of the form

$$h_t = \bar{h} + h_1\ V_{t-1} + h_2 V_{t-2}$$

can eliminate all of the cyclical components in p_t as well. No setting of θ can do this, but it would not seem to matter in the present setting. None of the agents in this model care about the (asymptotic) variance of p_t.

III. CONCLUSION:

The existence of an exploitable policy tradeoff between stability in labor markets and stability in financial markets depends upon how participants in those markets behave in response to instability. In the model outlined above, if participants in labor markets write one period labor contracts or if the relevant variance for portfolio managers is a one period conditional variance ($r^2_{t|t-1}$ in the language of section I), then there is no exploitable tradeoff. And in the case of two period labor contracts and asymptotic variances for portfolio managers, the existence of a policy tradeoff depends upon the source of the instability. Monetary policy can stabilize both markets in the face of monetary disturbances, but there is a tradeoff for aggregrate demand disturbances. It may be interesting to note that fiscal policy (if it were introduced in the model above) could stabilize both markets in the face of aggregate demand disturbances.[20] The monetary instrument is best placed to counter monetary disturbances while the fiscal instrument is best placed to counter disturbances in aggregate demand. One might speculate that a properly designed indexing scheme would be most efficient at offsetting productivity disturbances.

Such a scheme would not be of the type described above however; and it is doubtful that it would be much like any of the schemes in current use either. It is, of course, up to the reader to judge the relevance of the model outline above. There are other ways of explaining why instability matters and there are other ways of modeling agents' behavior in the face of instability. It is hoped, however, that the present analysis does illustrate in a convincing manner the inadequacy of policy models that fail to explain why the objectives of policy matter or fail to account for the way agents react to occurrences that are supposed to be important to them.

Appendix: Derivation of Equation (18)

Equation (18a) is just equation (10). Equations (10) and (14) imply

$$s z_t = - d(r_t - \pi) + U_t$$

and using (17) to eliminate r_t,

$$p_t = (m\pi - \gamma) - (ms/d)\; z_t + h_t + (m/d)\; U_t - V_t \equiv e - f\; z_t + x_t$$

This is equation (18b), and substituting into (17) (to eliminate p_t) produces equation (18c).

Deriving (18d) is somewhat more difficult. Equation (18b) is

$$p_t = e - f\; z_t + x_t$$

$$= e - f[(p_t - p_{t|t-1}) + (p_t - p_{t|t-2}) - \theta(p_{t-1} - p_{t-1|t-2})] + x_t$$

Taking the conditional expectation and subtracting

$$\hat{p}_{t|t-1} = p_t - p_{t|t-1} = -f[\hat{p}_{t|t-1} + \hat{p}_{t|t-1}] + \hat{x}_t$$

and thus

$$\hat{p}_{t|t-1} = (1 + 2f)^{-1} \hat{x}_{t|t-1} \qquad \text{(I)}$$

Substituting this back into (18b),

$$p_t = e - f \hat{p}_{t|t-2} - f(1 + 2f)^{-1} (\hat{x}_{t|t-1} - \theta\hat{x}_{t-1|t-2}) + x_t$$

Taking the conditional expectation and subtracting,

$$\hat{p}_{t|t-2} = p_t - p_{t|t-2}$$

$$= -f \hat{p}_{t|t-2} - f (1 + 2f)^{-1}[\hat{x}_{t|t-2} -(x_{t|t-1} - x_{t|t-2})$$

$$- \theta\hat{x}_{t-1|t-2}] + \hat{x}_{t|t-2}$$

Working with the bracketed expression

$$[-] = [\hat{x}_{t|t-2} - (x_t - x_{t|t-2} - (x_t - x_{t|t-1})) - \theta\hat{x}_{t-1|t-2}]$$

$$= [\hat{x}_{t|t-2} - \hat{x}_{t|t-2} + \hat{x}_{t|t-1} - \theta\hat{x}_{t-1|t-2}]$$

$$= \hat{x}_{t|t-1} - \theta\hat{x}_{t-1|t-2}$$

So, finally,

$$\hat{p}_{t|t-2} = -f \hat{p}_{t|t-2} -f(1 + 2f)^{-1}(\hat{x}_{t|t-1} - \theta\hat{x}_{t-1|t-2}) + \hat{x}_{t|t-2}$$

and

$$\hat{p}_{t|t-2} = (1 + f)^{-1}(\hat{x}_{t|t-2} - f(1 + 2f)^{-1}(\hat{x}_{t|t-1} - \hat{x}_{t-1|t-2})] \qquad \text{(II)}$$

Using (I) and (II),

$$z_t = \hat{p}_{t|t-1} + \hat{p}_{t|t-2} - \theta\hat{p}_{t-1|t-2}$$

$$= (1 + 2f)^{-1}(1 + f)^{-1}\,\hat{x}_{t|t-1} + (1 + f)^{-1}[\hat{x}_{t|t-2} - (1 + 2f)^{-1}\,\theta\hat{x}_{t-1|t-2}]$$

Recalling that f = ms/d , this expression becomes equation (18d) in the main text.

FOOTNOTES

[1] See Kalchbrenner and Tinsley (1976) or Shupp (1978). Actually, one need not resort to large models and computer simulations to document this tradeoff; it is apparent in simple IS-LM models. When aggregate demand is high and interest rates are already high, the FED has to raise interest rates even further if it is going to stabilize the goods market. Similarly, the FED has to make interest rates even lower in periods of slack demand.

[2] Some would argue that familiarity with the financial community must ultimately count for something.

[3] See, for example, Sargent's (1979) discussion of the "real bills" doctrine.

[4] For example, an increase in price variability might lead to more indexing in labor contracts. Few if any econometric models attempt to model this kind of response.

[5] This has been emphasized by Leitman and Wan (1978) and others.

[6] This scenario has come under attack recently. The "implicit contract" literature suggests that risk averse laborers would be willing to trade expected wages for employment security. If so, the equilibrium labor contract will probably not specify an employment rule that is consistent with period by period profit maximization. Barro (1977) has characterized the profit maximizing employment rule as pareto inferior. Fischer's (1977c) reply to Barro is also relevant. The basic scenario outlined above does seem to be consistent with certain stylized facts about actual labor markets. These markets are characterized by long-term contracts (one to three years in length), specifying nominal wage rates and sometimes (more frequently in Europe than in the U.S.) a "cost of living" adjustment scheme, the purpose of which seems to be to stabilize the real wage rate.

It would, of course, be preferable to allow the form of the contract (including the employment rule) to be endogenous, and perhaps varying with a change in government policy. This ambitious task is beyond the scope of the present paper.

[7] This simplicity is due to the fact that all of the randomness in the supply side of the economy comes from the price level. If productivity disturbances were specified, stabilizing real wages would no longer be equivalent to stabilizing employment and output. See, for example, Gray (1976).

[8] See, for example, Meditch (1969), chapter 5.

[9] This may be viewed as a strong form of the "rational expectations" hypothesis.

[10]See, for example Fischer (1977a) and Canzoneri (1980).

[11]See Canzoneri (1980) and Gray (1978) for attempts to make the length of the contract endogenous.

[12]There is, to my knowledge, no well developed theory explaining how indexing schemes evolve. This is a part of the more general problem discussed in footnote 6. Fischer's (1977b) "general" indexing is the broadest or most inclusive scheme possible; it effectively reduces long-term contracts to one period contracts and monetary policy loses its potency. However, as Fischer was quick to point out, there are no contracts in existence that incorporate such a broad scheme. The scheme postulated below does bear some resemblance to indexing schemes in actual use.

[13]If V is the variance of the price prediction error that would occur in period two without indexing, then $[1 - \rho^2]$ V is the variance that could be obtained with indexing (where ρ is the correlation coefficient for $\hat{p}_{t|t-2}$ and $\hat{p}_{t-1|t-2}$). See Meditch (1969), page 95.

[14]It might be noted that if θ is properly specified in the labor contracts, then this form of indexing can only stabilize labor markets. However, the indexing scheme described above can be given other interpretations: Equation (8) looks like an "adaptive" expectations mechanism, or this might be viewed as a "catch-up" type of scheme where workers are compensated in the second period for mistakes made in the first. Under either of these alternative interpretations, there is no reason to think that the indexing parameter θ will be chosen in accordance with equation (9), and this type of indexing may well destabilize labor markets.

[15]Letting π be defined as $p_{t+1|t-1} - p_{t|t-1}$ would result in the familiar non-uniqueness problem discussed by Shiller (1977) and others. For simplicity, π has been defined as the steady-state expected rate of inflation, which will turn out to be zero in the present model.

[16]One might also be tempted to introduce an indexation scheme analogous to the one described in part A, but this would not be very realistic. Indexing in financial markets--where it occurs--tends to take the form of ex post adjustments.

[17]This policy rule can be expressed in terms of observable variables; using (12),

$$h_t = \bar{h} - h[y_{t-1} - \bar{y} + d(r_{t-1} - \pi)]$$

[18]It might be noted that the governments of some countries have found indexing so difficult to deal with that they have attempted to outlaw it.

[19]Again this policy rule can be expressed in terms of observable variables; using (17)

$$h_t = \bar{h} + h[h_{t-1} - p_{t-1} + mr_{t-1} - \gamma]$$

[20]The interested reader can show this by introducing a term $d_1 g$ in the aggregate demand equation (14) and considering policy rules of the form

$$g_t = \bar{g} - g\, U_{t-1}$$

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FIGURE 1

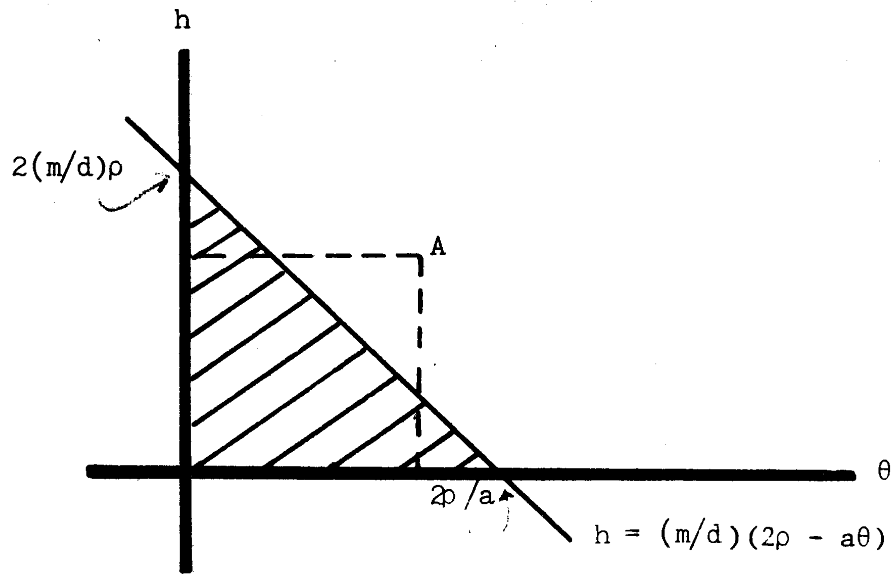

FIGURE 2