NBER WORKING PAPER SERIES

OPTIMAL MONETARY POLICY AND WAGE INDEXATION UNDER ALTERNATIVE DISTURBANCES AND INFORMATION STRUCTURES

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Working Paper No. 2042

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 1986

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NBER Working Paper #2042
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ABSTRACT

The interdependence between the optimal degree of wage indexation and optimal monetary policy is analyzed for a small open economy under a variety of assumptions regarding: (i) relative information available to private agents and the stabilization authority; (ii) the perceived nature of the disturbances impinging on the economy. The distinctions between: (a) unanticipated and anticipated disturbances, and (b) permanent and transitory disturbances, are emphasized. The extent to which stabilization is achieved is shown to depend upon the nature of the disturbances and the available information. The policy redundancy issue is emphasized, implying that optimal rules can frequently be specified in many equivalent ways.

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1. INTRODUCTION

Recent research in international macroeconomics has emphasized the interdependence between the degree of wage indexation and the choice of exchange rate regime from the viewpoint of optimal stabilization policy. Authors such as Marston (1982), Flood and Marion (1982), among others, have shown how: (i) the choice between fixed and flexible exchange rate systems depends upon the degree of wage indexation; (ii) the choice of the optimal degree of wage indexation depends upon the exchange rate regime.[1]

More recently, Turnovsky (1983) and Aizenman and Frenkel (1985) have begun to take a more integrated approach to the question of the optimal stabilization of an open economy, by analyzing general rules for wage indexation and monetary policy. These authors focus on the tradeoffs between these as stabilization instruments, and their approach is directed at the design of overall, integrated, stabilization policy 'packages.' Taking monetary policy to be in the form of exchange market intervention, Turnovsky showed how the degree of intervention impinges on the effectiveness of wage indexation, and vice versa. Full indexation of wages to prices renders exchange market intervention ineffective in stabilizing output. At the same time, intervention resulting in an accommodation of the domestic money supply precisely equal to the change in the demand for money due to movements in the exchange rate, makes wage indexation become totally ineffective.[2] Aizenman and Frenkel consider the joint determination of optimal indexation and optimal monetary policy among more general forms of monetary policy rules. Their analysis stresses the relationship between the number of independent pieces of information regarding the sources of stochastic disturbances impinging on the economy and the number of independent policy parameters.

The optimal policy literature deals almost exclusively with stabilizing white noise disturbances; i.e., the stochastic shocks impinging on the economy are unanticipated, transitory and are independently distributed over time.[3] In practice, the distinction between permanent and transitory disturbances, on the one hand, and anticipated and unanticipated disturbances, on the other, is an extremely important one. Different types of disturbances are reflected differently in the economy and require different policy responses. Some of these have been considered for monetary rules by Turnovsky (1984).

This paper addresses the interdependence between optimal monetary policy and optimal wage indexation in an economy in which the exogenous disturbances may be of a quite general type. The situation we envisage is an economy in which one-period wage contracts are signed in each period. These contracts introduce rigidities into the economy and the purpose of the monetary and wage indexation rules is to attempt to eliminate these rigidities and to replicate the behavior of a frictionless economy.

We assume that there are two types of random disturbances impinging on the economy. An important element in our analysis concerns the availability of information on these variables. First, there are price and financial variables, information on which is available to all agents instantaneously. Secondly, there are real and monetary shocks, which may or may not be observed contemporaneously. Indeed, we shall show how both the form of the optimal rules and, in some cases the ability to replicate the frictionless economy, depends critically upon the availability of information to agents in the economy.

2. THE FRAMEWORK

This section outlines the analytical framework. To minimize details, a simple model will be employed. We consider a small open economy which produces and consumes a single traded good. We also assume a single traded bond, with the domestic bond market being perfectly integrated with that in the rest of the world. Thus purchasing power parity (PPP) and uncovered interest parity (UIP) are assumed to hold.

A. *Availability of Information*

A key feature of our analysis concerns the availability of information. Our characterization of this is illustrated in Fig. 1, considered from the viewpoint of time t, which we partition into the infinitesimally short sub-period (t, t+).

At time t-1, a contract is signed for the wage at time t, this being determined on the basis of expectations formed at time t-1. Prices and financial variables are assumed to be observed instantaneously by all agents, so that everyone has complete current information on these variables when they make their respective decisions. More specifically, these instantaneously observed variables include:

(i) the domestic and foreign interest rates;

(ii) the exchange rate;

(iii) the domestic price level.

Given PPP, (ii) and (iii) imply the observability of the foreign price level as well.

At time t, two sets of decisions are made. First, there are policy decisions; i.e., the implementation of the wage indexation and monetary policy rules. Here we assume, largely for expositional simplicity, that wage indexation is conducted by a public authority, as indeed is the case in countries such as Israel and Australia. This has the advantage of enabling us to identify all stabilization activities as being conducted by a public authority. Secondly, there are the decisions of the private agents in the economy, which include the production, portfolio, and consumption decisions, as well as the formation of forecasts for the next period. We assume that these two sets of decisions are made in the above order, at instances we denote by t, t+, respectively. This means that the actual indexed wage, which is determined at time t, is known by the time the production decision is made at the next instant of time, t+.

This distinction in effect differentiates the information available to the public and private agents in the economy. It is possible to make further distinctions among the various private agents along the lines of Canzoneri, Henderson, and Rogoff (1983). For example, one can allow investors, who form predictions of the future exchange rate, to have different information from individuals concerned with predicting prices in the determination of the wage contract. And their information may differ from that of producers. We do not pursue these refinements here.

The key informational issue concerns the observability of the domestic monetary disturbance, u_t say, and the domestic productivity disturbance, v_t say. Under our assumptions, three different informational situations exist:

(i) u_t, v_t are observed instantaneously at time t by both public and private agents.

As we shall show, this full information assumption is in effect the information structure considered by Karni (1983) and indeed, we shall obtain a modified form of his indexation rule as one optimal policy.[4]

(ii) u_t, v_t are observed in the time interval (t, t+). They are therefore unobserved by the stabilization authority, but known to private agents.

This asymmetric information assumption is made throughout much of the literature; see e.g. Gray (1976), Canzoneri (1982), Turnovsky (1983), and several of the papers in Bhandari (1985).

(iii) u_t, v_t are observed after time t+. They are therefore unknown to both public and private agents at the time decisions for time t are made.

In this case, agents form estimates of u_t, v_t at time t, as required for production or forecasting decisions, by utilizing information on the observed financial variables. This information structure is again symmetric between public and private agents and is the one adopted by Aizenman and Frenkel (1985).

B. *The Demand Side*

The demand side of the economy is summarized by the following three equations:

$$P_t = Q_t + E_t \tag{1}$$

$$R_t = \Omega_t + E^*_{t+1,t} - E_t \tag{2}$$

$$M_t - P_t = \alpha_1 Y_t - \alpha_2 R_t + u_t \tag{3}$$

where

P_t = price of domestic output, expressed in logarithms,

Q_t = price of foreign output, expressed in logarithms,

E_t = exchange rate, expressed in logarithms,

$E^*_{t+1,t}$ = forecast of E_{t+1}, formed at time t,

Ω_t = foreign nominal interest rate,

Y_t = domestic output, expressed in logarithms,

u_t = stochastic disturbance in the demand for money.

These equations are standard. Equation (1) describes PPP; equation (2) specifies UIP; equation (3) describes equilibrium in the domestic monetary sector.

C. The Supply Side

The supply function is based on the one-period wage contract model. We assume that the contract wage for time t is determined at time t-1 such that, given expectations of firms and workers, the labor market is expected to clear. The information set upon which the contract is based includes all financial and price variables up till and including time $t-1$; i.e., all past stochastic disturbances. It may, or may not, include the actual disturbances occurring at that time. In terms of our timing scheme, the contract for time t is signed at time $(t-1)+$.

The expected supply of labor at the contract wage is

$$N^s_{t,t-1} = n(W^c_{t,t-1} - P^*_{t,t-1}) \qquad n > 0 \tag{4}$$

where

$N^s_{t,t-1}$ = expected supply of labor formed at time t-1, for time t, expressed in logarithms,

$W^c_{t,t-1}$ = contract wage, determined at time t-1 for time t, expressed in logarithms,

$P^*_{t,t-1}$ = forecast of P_t formed at time t-1.

Output is produced by means of a Cobb-Douglas production function

$$Y_t = (1-\theta)N_t + v_t \qquad 0 < \theta < 1 \tag{5}$$

where

N_t = employment of labor, expressed in logarithms,

v_t = stochastic disturbance in productivity.

The expected demand for labor, $N^d_{t,t-1}$, (based on expected profit maximization), is determined by the marginal productivity condition

$$\ln(1-\theta) - \theta N^d_{t,t-1} + v^*_{t,t-1} = W^c_{t,t-1} - P^*_{t,t-1} \tag{6}$$

The contract wage is determined by equating the expected demand and supply of labor in (1) and (5), yielding

$$W^c_{t,t-1} = P^*_{t,t-1} + \frac{\ln(1-\theta)}{1+n\theta} + \frac{v^*_{t,t-1}}{1+n\theta} \tag{7}$$

The contract wage therefore depends upon the expected productivity disturbance as well as the expected price level.

Actual employment is assumed to be determined by the short-run marginal productivity condition, after the actual wage and price are known. This is expressed by

$$\ln(1-\theta) - \theta N_t + \mathrm{E}_t(v_t) = W_t - P_t \tag{8}$$

Note that we have introduced the instantaneous forecast of the productivity disturbance, denoted by $\mathrm{E}_t(v_t)$, into the optimality condition (8). This allows for the possibility that firms do not observe this disturbance instantaneously.[5] If it is observed, then $\mathrm{E}_t(v_t) = v_t$; otherwise they must infer it from available information on current observable variables, using a forecasting technique we discuss below. Combining (5) and (8), current output is given by,

$$Y_t = \left(\frac{1-\theta}{\theta}\right)\ln(1-\theta) + \left(\frac{1-\theta}{\theta}\right)(P_t - W_t) + \left(\frac{1-\theta}{\theta}\right)\mathrm{E}_t(v_t) + v_t \tag{9}$$

which depends upon both the firm's estimate of v_t and v_t itself. In the event that v_t is observed, (9) simplifies to

$$Y_t = (\frac{1-\theta}{\theta}) \ln(1-\theta) + (\frac{1-\theta}{\theta}) (P_t - W_t) + \frac{v_t}{\theta} \tag{9'}$$

D. Wage Indexation

In the situation that the productivity disturbance is observed instantaneously, the optimal form of the wage indexation rule will become immediately apparent and will be discussed later. Otherwise, we assume that wages are indexed in accordance with the simple rule

$$W_t = W^c_{t,t-1} + \tau (P_t - P^*_{t,t-1}) \tag{10}$$

where τ is the indexation parameter to be determined. Combining (10) and (7) with (9) or (9'), yields the following alternative forms of supply functions, which correspond to the observability or otherwise of the productivity disturbance,

$$Y_t = \frac{(1-\theta)\, n \ln(1-\theta)}{1 + n\theta} + (1-\tau)(\frac{1-\theta}{\theta})(P_t - P^*_{t,t-1}) + (\frac{1-\theta}{\theta}) \left[E_t(v_t) - \frac{v^*_{t,t-1}}{1 + n\theta} \right] + v_t \tag{11}$$

$$Y_t = \frac{(1-\theta)\, n \ln(1-\theta)}{1 + n\theta} + (1-\tau)(\frac{1-\theta}{\theta})(P_t - P^*_{t,t-1}) + \frac{v_t}{\theta} - (\frac{1-\theta}{\theta}) \frac{v^*_{t,t-1}}{1 + n\theta} \tag{11'}$$

E. Monetary Policy Rule

In the case that the monetary authorities observe all disturbances instantaneously, the optimal rule becomes self-evident. Otherwise, we assume that the monetary authorities adjust the money supply in accordance with observed movements in the financial and price variables

$$M_t = \nu_1 E_t + \nu_2 R_t + \nu_3 \Omega_t + \nu_4 P_t$$

Using the PPP condition (1) and the UIP condition (3), this equation can be expressed as

$$M_t = \mu_1 E_t + \mu_2 E^*_{t+1,t} + \mu_3 \Omega_t + \mu_4 Q_t$$

Note that the money supply is assumed to be adjusted to a wider range of pieces of information than are wages. This reflects the prevailing practice of wage indexation being restricted to price movements. If, in addition, wages are assumed to be indexed to the foreign price level, nothing additional is gained as long as the money supply is adjusted to the foreign price level as well. There is a tradeoff between μ_4 and the corresponding coefficient in the wage indexation rule.

We will argue below that wage indexation is inessential. The optimum we achieve can always be obtained by monetary policy alone. In some cases, it can also be achieved by a comprehensively based wage indexation scheme. But this is not always so. In one important case, monetary policy is always required to achieve the optimal degree of stability.

F. The Frictionless Economy

Wage contracts introduce rigidities into the economy, leading to welfare losses relative to a frictionless economy in which wages are fully flexible. The purpose of stabilization policy is to attempt to 'undo' these, thereby replicating as closely as possible the output of a frictionless economy, and minimizing these resulting welfare losses. It is well known that the supply of output in such an economy is given by

$$Y_t^f = \frac{n(1-\theta)}{1+n\theta}\ln(1-\theta) + \frac{n(1-\theta)}{1+n\theta}E_t(v_t) + v_t \tag{13}$$

In the case that firms observe v_t instantaneously, (13) reduces to

$$Y_t^f = \frac{n(1-\theta)}{1+n\theta}\ln(1-\theta) + \left(\frac{1+n}{1+n\theta}\right)v_t \tag{13'}$$

The output level of the frictionless economy thus serves as a benchmark, with the stabilization objective being to minimize the variance of Y_t about Y_t^f.[6]

G. The Complete Model

The above components can now be combined to yield the following summary of the economy. It is expressed in deviation form, about an initial equilibrium, these deviations being denoted by lower case letters. Thus we obtain

$$p_t = q_t + e_t \tag{14a}$$

$$m_t - p_t = \alpha_1 y_t - \alpha_2[\omega_t + e^*_{t+1,t} - e_t] + u_t \tag{14b}$$

$$m_t = \mu_1 e_t + \mu_2 e^*_{t+1,t} + \mu_3 \omega_t + \mu_4 q_t \tag{14c}$$

$$y_t = \left(\frac{1-\theta}{\theta}\right)\left[(1-\tau)[(e_t - e^*_{t,t-1}) + (q_t - q^*_{t,t-1})] + \mathrm{E}_t(v_t) - \frac{v^*_{t,t-1}}{1+n\theta}\right] + v_t \tag{14d}$$

$$y^f_t = \frac{n(1-\theta)}{1+n\theta}\mathrm{E}_t(v_t) + v_t \tag{14e}$$

All expectations are assumed to be rational

$$x^*_{s,t} = \mathrm{E}_t(x_s) \quad s > t$$

where E_t is the expectations operator, conditional on information available at time t. Note that in the case that v_t is observed instantaneously to private agents, $\mathrm{E}_t(v_t) = v_t$, and (14d) and (14e) are amended appropriately. Also, in writing the supply function as in (14d), the one period conditional expectation of (14a) has been taken and substituted. Finally, we should emphasize that our notation (t, t+) introduced above is to parameterize the information sets available to the agents in the economy. All variables in the infinitesimal time interval (t, t+) are determined simultaneously.

3. GENERAL SOLUTION

The reduced form system (14) is a standard rational expectations macro model. The solution procedures are familiar, enabling our description to be brief.

First, we consider the observability of the stochastic disturbances implied by the observability of the financial variables and prices. With m_t being adjusted in accordance with a known rule in response to observed variables, $m_t - p_t$ is observed at time t. Substituting for output from (14d) into (14b), we have

$$m_t - p_t = \alpha_1(\frac{1-\theta}{\theta})\left[(1-\tau)\,[(e_t - e^*_{t,t-1}) + (q_t - q^*_{t,t-1})] + E_t(v_t) - \frac{v^*_{t,t-1}}{1+n\theta}\right] - \alpha_2 r_t + (u_t + \alpha_1 v_t) \tag{15}$$

The quantities e_t, $e^*_{t,t-1}$, q_t, $q^*_{t,t-1}$, $E_t(v_t)$, $v^*_{t,t-1}$, r_t, are all observed at time t, enabling us to deduce the value of the composite disturbance $(u_t + \alpha_1 v_t)$. Thus assuming that u_t, v_t are uncorrelated, the optimal estimates of u_t, v_t, obtained from the observed composite disturbance, are given by the least squares predictors

$$E_t(u_t) = \frac{\sigma_u^2}{\sigma_u^2 + \alpha_1^2\sigma_v^2}(u_t + \alpha_1 v_t) \tag{16a}$$

$$E_t(v_t) = \frac{\alpha_1\sigma_v^2}{\sigma_u^2 + \alpha_1^2\sigma_v^2}(u_t + \alpha_1 v_t) \tag{16b}$$

where σ_u^2, σ_v^2 are the variances of u_t, v_t respectively.

For notational convenience define

$$z_t \equiv u_t + \frac{\alpha_1(1+n)}{1+n\theta}v_t + (1-\mu_4)q_t - (\alpha_2 + \mu_3)\omega_t \tag{17}$$

The conditional expectations for time t+j, formed at time t, are

$$z^*_{t+j,t} = u^*_{t+j,t} + \frac{\alpha_1(1+n)}{1+n\theta}v^*_{t+j,t} + (1-\mu_4)q^*_{t+j,t} - (\alpha_2+\mu_3)\omega^*_{t+j,t} \qquad j = 0,1,2,\ldots \tag{18}$$

The instantaneous forecast, $z^*_{t,t}$ depends upon the observability of u_t, v_t. In general, we have

$$\begin{aligned} E_t(z_t) \equiv z^*_{t,t} &= E_t(u_t) + \frac{\alpha_1(1+n)}{1+n\theta} E_t(v_t) + (1-\mu_4)q_t - (\alpha_2+\mu_3)\omega_t \\ &= z_t + \frac{\alpha_1(1-\theta)n}{1+n\theta}[E_t(v_t) - v_t] \end{aligned} \tag{18'}$$

with $z^*_{t,t} = z_t$, when v_t is observed.

Substituting (14a), (14c), (14d) into (14b) and taking conditional expectations, yields the following difference equation in exchange rate expectations:

$$(\alpha_2 + \mu_2)\, e^*_{t+i+1,t} - (1-\mu_1 + \alpha_2)\, e^*_{t+i,t} = z^*_{t+i,t} \quad i = 1,2,... \tag{19}$$

Thus with this notation, we can show that the deviation of output from its frictionless level, $y_t - y^f_t$, is given by

$$\begin{aligned} y_t - y^f_t = \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right) \Bigg\{ &(1+\alpha_2-\mu_1)\left[(1-\tau)\left[-e^*_{t,t-1} + (q_t - q^*_{t,t-1})\right] + \frac{E_t(v_t) - v^*_{t,t-1}}{(1+n\theta)}\right] \\ &+ (1-\tau)\left[-z_t + (\mu_2+\alpha_2)\, e^*_{t+1,t} + \frac{\alpha_1(1-\theta)n}{1+n\theta}[v_t - E_t(v_t)]\right] \Bigg\} \end{aligned} \tag{20}$$

where $\Delta \equiv 1-\mu_1 + \alpha_2 + \alpha_1(\frac{1-\theta}{\theta})(1-\tau)$. The exchange rate expectations $e^*_{t+1,t}$ and $e^*_{t,t-1}$ are obtained by solving (19) and are given by[7]

$$e^{*}_{t+1,t} = -\frac{1}{1-\mu_1+\alpha_2}\left[\sum_{j=0}^{\infty} z^{*}_{t+1+j,t}\left(\frac{\alpha_2+\mu_2}{1-\mu_1+\alpha_2}\right)^{j}\right] \quad \text{if} \quad \left|\frac{1-\mu_1+\alpha_2}{\alpha_2+\mu_2}\right| > 1 \qquad (21a)$$

$$= \frac{1}{\alpha_2+\mu_2}\left[\sum_{j=0}^{\infty} z^{*}_{t-j,t}\left(\frac{1-\mu_1+\alpha_2}{\alpha_2+\mu_2}\right)^{j}\right] \quad \text{if} \quad \left|\frac{1-\mu_1+\alpha_2}{\alpha_2+\mu_2}\right| < 1 \quad \text{for all t} \qquad (21b)$$

where $z^{*}_{t+j,t}$ is defined by (18), (18').[8] Furthermore, setting i = 1 in (19) (at time t-1), using (18'), and substituting into (20), the deviation in output can be written equivalently as:

$$y_t - y_t^f = \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right)\Big\{(1-\tau)\left[(\mu_2+\alpha_2)\left(e^{*}_{t+1,t} - e^{*}_{t+1,t-1}\right) - \left(E_t(z_t) - z^{*}_{t,t-1}\right)\right]$$
$$+ (1+\alpha_2-\mu_1)\left[(1-\tau)\left(q_t - q^{*}_{t,t-1}\right) + \frac{E_t(v_t) - v^{*}_{t,t-1}}{1+n\theta}\right]\Big\} \qquad (20')$$

This equation indicates that the deviation in output from the frictionless level depends upon revisions to forecasts made between time t-1 and time t in response to new information. In the case of observed variables, such as q_t, this is the unanticipated change in that variable. In the case of exchange rate expectations, it is the update in the forecast for time t+1, between time t-1 and time t.

Our analysis below includes two important cases. The first is where all disturbances are unanticipated and transitory, so that

$$e^{*}_{t+1,t} = 0 \qquad \text{for all t} \qquad (22)$$

The second is where the expectations of the composite variable z formed at time t are uniform throughout all future periods. Formally, this is described by

$$z^{*}_{t+i,t} = z^{*}_{t} \text{ say, } i = 1,2, \cdots, \text{for all t} \qquad (23)$$

In particular, we consider the important case where the current disturbance in z_t is expected to be permanent so that $z_t^* = E_t(z_t)$. In this case, the stable solution for exchange rate expectations both simplify to

$$e^*_{t+1,t} = \frac{-E_t(z_t)}{1 - \mu_1 - \mu_2} \quad i = 1,2, ..., \text{for all t} \tag{24}$$

4. FULL INFORMATION

Stabilization when both private agents and the stabilization authority have complete information on all random disturbances, including u_t, v_t, is straightforward, either by means of wage indexation or monetary policy.

Subtracting (13') from (9'), using (7), and writing the resulting expression in deviation form about the initial equilibrium, yields

$$y_t - y_t^f = \left(\frac{1-\theta}{\theta}\right)\left[(p_t - p^*_{t,t-1}) - (w_t - w^c_{t,t-1}) + \frac{(v_t - v^*_{t,t-1})}{1 + n\theta}\right] \tag{25}$$

so that $y_t = y_t^f$, the frictionless level, provided wages are indexed in accordance with

$$w_t = w^c_{t,t-1} + (p_t - p^*_{t,t-1}) + \frac{1}{1 + n\theta}[v_t - v^*_{t,t-1}] \tag{26}$$

That is, wages should be fully indexed to the unanticipated change in price and partially indexed to the unanticipated component of the productivity shock. Full indexation to the price change alone yields perfect stabilization if and only if the productivity disturbance is fully anticipated. Equation (26) may be rewritten as

$$w_t = w_t^c + (p_t - p^*_{t,t-1}) + \frac{1}{1 + n}[y_t - y^*_{t,t-1}] \tag{27}$$

with the rule now being expressed in terms of unanticipated movements in output. This rule is essentially equivalent to the Karni (1983) stabilization rule, which dealt with unanticipated disturbances.

Alternatively, subtracting (13') from the money market equilibrium condition, we obtain

$$y_t - y_t^f = \frac{1}{\alpha_1}\left[m_t - p_t - u_t + \alpha_2 r_t - \alpha_1\left(\frac{1+n}{1+n\theta}\right)v_t\right]$$

so that for perfect stabilization, $y_t = y_t^f$, we require

$$m_t = p_t - \alpha_2 r_t + u_t + \alpha_1\left(\frac{1+n}{1+n\theta}\right)v_t \tag{28}$$

Equations (26) and (28) provide alternative methods for replicating the output of the frictionless economy. Each of these offers advantages. The wage indexation scheme involves monitoring fewer pieces of information, although it does involve formulating forecasts of the productivity disturbance. On the other hand, the monetary rule requires more information, but observations on only *current* disturbances. Moreover, the authority need not attempt to determine whether a disturbance is permanent or transitory. Its nature will be reflected by movements in the (observed) interest rate. Finally, eliminating p_t between (26) and (28) yields a tradeoff between the adjustment in money supply and the wage rate.

5. UNANTICIPATED DISTURBANCES

We now return to equation (20) and determine the optimal monetary policy and wage indexation schemes in situations where there is incomplete information. The optimal policy rules are summarized in Table 1. The first row of that table deals with Case (ii), where private agents, but not the stabilization authority, observe the demand and productivity disturbances u_t, v_t; the second row describes Case (iii) where neither the private agents not the stabilization authority observe u_t, v_t. The two columns of the table pertain respectively to white noise disturbances and to disturbances which, having occurred, are then perceived as being permanent.

These optimal policies are determined as follows. Depending upon the disturbance, $e^*_{t+1,t}$, $e^*_{t,t-1}$ are calculated from (21) and substituted into (20). The policy parameters, μ_i, and

τ, are chosen to minimize var $(y_t - y_t^f)$.

A. White Noise Disturbances

For white noise disturbances all expectations are zero, so from (22)

$$e^*_{t+1,t} = e^*_{t,t-1} = 0$$

Thus, substituting into (20')

$$y_t - y^f = \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right)\left\{-(1-\tau)\,E_t(z_t) + (1+\alpha_2-\mu_1)\left[(1-\tau)q_t + \frac{E_t(v_t)}{1+n\theta}\right]\right\}$$

$$= \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right)\left\{-(1-\tau)(u_t+\alpha_1 v_t) + \left[\frac{(1+\alpha_2-\mu_1)-(1-\tau)\alpha_1(1-\theta)n}{1+n\theta}\right]E_t(v_t)\right. \quad (29)$$

$$\left. + (1+\tau)(\alpha_2-\mu_1+\mu_4)q_t + (1-\tau)(\alpha_2+\mu_3)\omega_t\right\}$$

Note that the solution is independent of the monetary policy parameter μ_2. This is because for white noise disturbances, $e^*_{t+1,t} = 0$. It is evident from (29) that the values of the optimal policy parameters which minimize var $(y_t - y_t^f)$ can be obtained recursively. First, the effects of the foreign variables q_t, ω_t, can be neutralized by setting their respective coefficients in (29) to zero; then the remaining variance due to the domestic variables u_t, v_t, can be minimized.

Full wage indexation is non-optimal, since when $\tau = 1$, (29) reduces to

$$y_t - y_t^f = \left(\frac{1-\theta}{\theta}\right)\frac{v_t}{1+n\theta}$$

rendering monetary policy ineffective for further variance reduction. Instead, the effects of the foreign variables can be eliminated by setting the optimal monetary policy parameters (denoted by n)

$$\hat{\mu}_3 = -\alpha_2 \tag{30a}$$

$$\hat{\mu}_4 = -\alpha_2 + \hat{\mu}_1 \tag{30b}$$

With the foreign variables eliminated, (29) simplifies to

$$y_t - y_t^f = \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right)\left\{-(1-\tau)(u_t + \alpha_1 v_t) + \left[\frac{(1+\alpha_2-\mu_1)-(1-\tau)\alpha_1(1-\theta)n}{1+n\theta}\right]E_t(v_t)\right\} \tag{29'}$$

The remaining choice is that of τ, μ_1, and this depends critically upon whether or not v_t is observed.

If v_t is observed, then $E_t(v_t) = v_t$, and it is easy to show that only one of the remaining policy parameters $\hat{\tau}$, $\hat{\mu}_1$, can be chosen independently. The optimal choice is constrained by the relationship

$$\left(\frac{1+\alpha_2-\hat{\mu}_1}{1+n\theta}\right)\phi = (1-\hat{\tau})\left[\theta + \alpha_1\phi(1-\theta) + \frac{\alpha_1 n(1-\theta)\phi}{1+n\theta}\right] \tag{31}$$

where

$$\phi \equiv \frac{\alpha_1\sigma_v^2}{\sigma_u^2 + \alpha_1^2\sigma_v^2}$$

Equation (31) implies a tradeoff between the degree of wage indexation and the extent to which monetary policy should respond to exchange rate movements. Either τ or μ_1 can be chosen arbitrarily, with the other being determined by this relationship. The values $\tau = 1$, $\mu_1 = (1 + \alpha_1)$ are ruled out for reasons established previously by Turnovsky (1983) and noted above in Section 1. From (31) we see

$$\frac{d\hat{\mu}_1}{d\hat{\tau}} > 0$$

so that if wages are more fully indexed to prices, then the money supply should be expanded more (or contracted less) to a depreciation in the exchange rate.

Substituting (30a), (30b) into (14c) and using the PPP and UIP relationships, the optimal policies can be specified very simply by

$$m_t = (\hat{\mu}_1 - \alpha_2)p_t - \alpha_2 r_t \tag{32a}$$

$$w_t = \hat{\tau} p_t \tag{32b}$$

where $\hat{\mu}_1$, $\hat{\tau}$, are linked by (31). Written in this way, both optimal policy rules have the convenience of enabling the domestic policy makers to monitor only domestic variables. In particular, one component of the optimal monetary rule requires accommodation to movements in the demand for money arising from changes in the interest rate. If $\hat{\tau} = 0$, the optimum can be reached through monetary policy alone, with $\hat{\mu}_1$ being set in accordance with (31).[9]

Turning now to the case where u_t and v_t are not observed by private agents, we have from (16b)

$$E_t(v_t) = \phi(u_t + \alpha_1 v_t) \tag{33}$$

in which case (29') becomes

$$y_t - y_t^f = \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right)\left\{-(1-\tau) + \left[\frac{(1+\alpha_2-\mu_1)-(1-\tau)\alpha_1(1-\theta)n}{1+n\theta}\right]\phi\right\}(u_t + \alpha_1 v_t) \tag{29''}$$

The optimal policy parameters, $\hat{\mu}_1$, $\hat{\tau}$, obtained by setting the coefficient of the composite disturbance $(u_t + \alpha_1 v_t)$ to zero in (29) now satisfy

$$\frac{(1+\alpha_2-\hat{\mu}_1)}{1+n\theta}\phi = (1-\hat{\tau})\left[1 + \frac{\alpha_1(1-\theta)n\phi}{1+n\theta}\right] \tag{34}$$

which again implies a positive tradeoff between them. In this case, the slope is steeper than before, implying that for a given degree of indexation, a greater monetary expansion (smaller monetary contraction) is required in response to a given depreciation in the exchange rate. Substituting (30a), (30b) into (14c) and using the PPP and UIP conditions, the optimal policy rules are again given by (32a), (32b), except the tradeoff between $\hat{\mu}_1$ and $\hat{\tau}$ is now given by (34).

There is, however, a critical difference between these two cases. When private agents observe u_t and v_t, the optimal stabilization rule, based on incomplete information, is unable to replicate the output of the frictionless economy. In effect, the inferior information available to the stabilization authority prevents it from being able to track the behavior of a private frictionless economy perfectly. There is therefore some residual, positive var $(y_t - y_t^f)$. By contrast, when these disturbances are not observed by private agents, the optimal rules, with $\hat{\mu}_1$, $\hat{\tau}$, satisfying (34) imply $y_t = y_t^f$. With equal (imperfect) information to that of the private sector, the stabilization authority is able to replicate exactly the behavior of a frictionless economy. The latter is precisely the result obtained by Aizenman and Frenkel (1985).

B. Perceived Permanent Disturbances

Suppose now that the disturbances occurring at each point of time t have been previously unanticipated, but having occurred are now perceived as being permanent. Thus $q^*_{t,t-1} = q_{t-1}$, $v^*_{t,t-1} = E_{t-1}(v_{t-1})$ and $z^*_{t+j,t} = E_t(z_t)$ for all j and t. Thus exchange rate expectations are generated by

$$e^*_{t+1,t} = -\frac{E_t(z_t)}{1-\mu_1-\mu_2} \tag{35a}$$

$$e^*_{t+1,t-1} = -\frac{E_{t-1}(z_{t-1})}{1-\mu_1-\mu_2} \tag{35b}$$

where $E_t(z_t)$ is given by (18').

Substituting these expressions for expectations into (20'), the solution for $y_t - y_t^f$ is given by

$$y_t - y_t^f = (1 + \alpha_2 - \mu_1)\left[(1-\tau)(q_t - q_{t-1}) + \frac{E_t(v_t) - E_{t-1}(v_{t-1})}{1 + n\theta} - \frac{(1-\tau)[E_t(z_t) - E_{t-1}(z_{t-1})]}{1 - \mu_1 - \mu_2}\right] \tag{36}$$

From (36) we can obtain the expressions for the optimal policies reported in the second column of Table 1.

In the case where private agents, but not the stabilization authority, observe u_t, and v_t, we see by inspection that y_t is stabilized perfectly at the frictionless level, y_t^f, for all t, by setting $\mu_1 = (1 + \alpha_2)$. The optimal policy rules are therefore

$$m_t = (1 + \alpha_2)e_t + \mu_2 e^*_{t+1,t} + \mu_3\omega_t + \mu_4 q_t \tag{37a}$$

$$w_t = w^e_{t,t-1} + \tau(p_t - p^*_{t,t-1}) \tag{37b}$$

where μ_2, μ_3, μ_4, τ, are all arbitrary, the only restriction being $\tau \neq 1$. This is a generalization of the result obtained by Turnovsky (1984) in the absence of wage indexation.

To understand the economic reasoning underlying this result, consider the domestic money market. Combining equations (14a), (14b) yields

$$m_t = q_t + e_t + \alpha_1 y_t - \alpha_2[\omega_t + e^*_{t+1,t} - e_t] + u_t \tag{38}$$

If the domestic monetary authority intervenes in accordance with (37a), it follows from (35a) (and the assumption that u_t, v_t are observed by private agents) that

$$e^*_{t+1,t} = \frac{1}{\alpha_1 + \mu_2}\left[u_t + \frac{\alpha_1(1+n)}{1+n\theta}v_t - (\alpha_2 + \mu_3)\omega_t + (1 - \mu_4)q_t\right] \tag{39}$$

Exchange rate expectations adjust in response to the disturbances in u_t, v_t, ω_t, and q_t. The resulting adjustment in the domestic interest rate is precisely such as to eliminate the effects of the disturbances u_t, ω_t, and q_t from the excess demand for nominal money balances. This can be seen by substituting (39) and (37a) into (38):

$$(1 + \alpha_2) + \mu_3\omega_t + \mu_4 q_t = q_t + e_t + \alpha_1 y_t - \left[u_t + \frac{\alpha_1(1+n)}{(1+n\theta)}v_t + (1-\mu_4)q_t - (\alpha_2+\mu_3)\omega_t\right] - \alpha_2(\omega_t - e_t) + u_t \tag{40}$$

It is clear from this equation that whatever arbitrary values of μ_2, μ_3 and μ_4 are chosen, the expected exchange rate, given by the term in parentheses, simply adjusts to offset these stochastic effects. Upon simplification, (40) reduces to

$$y_t = \left(\frac{1+n}{1+n\theta}\right)v_t = y_t^f \tag{41}$$

thereby verifying that income is stabilized at its frictionless level.

It is interesting to note that in contrast to the white noise disturbances discussed above, the stabilization authority having incomplete information, can nevertheless replicate the equilibrium of a frictionless economy in response to this type of disturbance. It can dispense with wage indexation, and in fact, in the light of the PPP and UIP conditions, the optimal monetary rule can be expressed in a number of equivalent ways, e.g.,

$$m = (1+\alpha_2)e; \quad m = (1+\alpha_2)p; \quad m = (1+\alpha_2)r$$

The most convenient form will presumably depend upon the availability and reliability of the necessary information.

The situation where private agents do not observe u_t, v_t, leads to *two* sets of optimal policy rules, both of which yield perfect stabilization at the frictionless output level, for all t. Since (36) does not depend upon the observability of u_t, v_t, one optimal policy is obviously $\mu_1 = (1 + \alpha_2)$, again giving rise to (37a), (37b).

The term in parentheses in (36) can be written in terms of the differences Δq_t, $\Delta\omega_t$, and $\Delta(u_t + \alpha_1 v_t)$ The second set of policy rules is obtained by setting the coefficients of these random variables to zero, thereby setting the right-hand side of (36) to zero. The resulting optimum is similar, but not identical to, that obtained previously. Specifically, $\hat{\mu}_3 = -\alpha_2$, $\hat{\mu}_4 = \hat{\mu}_1 + \hat{\mu}_2$ with $\hat{\mu}_1$, $\hat{\mu}_2$, $\hat{\tau}$, being arbitrary, but subject to the constraint

$$\frac{(1-\hat{\mu}_1-\hat{\mu}_2)\phi}{1+n\theta} = (1-\hat{\tau})[1+\frac{\alpha_1(1-\theta)n\theta}{1+n\theta}]$$

If further, we choose $\hat{\mu}_2 = -\alpha_2$, then this second set of policy rules reduces to (32a), (32b), with the tradeoff between $\hat{\mu}_1$, $\hat{\tau}$, again being given by (34). This is identical to the optimal policy under white noise disturbances.

C. Uncertain Perceptions

Thus far, we have assumed that private agents are clear in their perceptions of whether the observed disturbances are permanent shifts or only transitory shocks. Of course in time they may turn out to be wrong, but our assumption is that agents can form a subjective characterization of them. Suppose instead, that agents are unable to decide whether a disturbance which has occurred represents a permanent shift or only a transitory shock. Assume that they formalize their uncertainty by assigning probabilities θ, $1-\theta$ say, respectively, to these two outcomes.[10] In the case where private agents observe u_t, v_t, the expected exchange rate is

$$e^*_{t+1,t} = -\frac{\theta z_t}{1-\mu_1-\mu_2}$$

and the analysis can be carried out by substituting this expression into (20). In this case it can be shown that if $\theta < 1$, perfect stabilization about the frictionless level of output is not possible. On the other hand, if private agents do not observe u_t, v_t, we have seen that the rules (32a), (32b), together with (34) replicate the frictionless economy perfectly for both white noise or permanent shifts. This rule will therefore yield perfect stability irrespective of the private agents' perceptions of the nature of the shocks (i.e., for *all* values of θ).

6. ANTICIPATED DISTURBANCES

As another example, suppose that at time t-1 agents perfectly anticipate all disturbances for time t (but not necessarily beyond). In the case of the instantaneously observed variables, this means, for example $q^*_{t,t-1} = q_t$; while for the potentially unobserved variables

$v^*_{t,t-1} = E_t(v_t)$. That is, no new information on v_t is forthcoming between time t-1 and t, so that the one-period prediction equals the future (noisy) observation. It then follows that $z^*_{t,t-1} = E_t(z_t)$ so that (20') reduces to

$$y_t - y_t^f = \frac{1}{\Delta}\left(\frac{1-\theta}{\theta}\right)(1-\tau)(\mu_2 + \alpha_2)(e^*_{t+1,t} - e^*_{t+1,t-1}) \qquad (20'')$$

In this case, perfect stabilization about the frictionless economy can be easily accomplished in either of two ways:

(i) full wage indexation, $\tau = 1$;

(ii) a monetary policy rule with $\mu_2 = -\alpha_2$.

The operation of the indexation rule can be seen by comparing (14d) with (14e). Full indexation eliminates the dependence of output on price movements, so that

$$y_t = \left(\frac{1-\theta}{\theta}\right)\left[E_t(v_t) - \frac{v^*_{t,t-1}}{1+n\theta}\right] + v_t$$

That is, employment and output depend primarily upon the change in the forecast of the supply shock between time t-1 and t. If $v^*_{t,t-1} = E_t(v_t)$ then

$$y_t = \frac{n(1-\theta)}{1+n\theta}E_t(v_t) + v_t = y_t^f$$

implying perfect stabilization about the frictionless level of output.

Alternatively, the monetary policy rule

$$m_t = \mu_1 e_t - \alpha_2 e^*_{t+1,t} + \mu_3 \omega_t + \mu_4 q_t$$

also leads to the perfect stabilization of output about y_t^f. The reason for this is that with $E_t(v_t) = v^*_{t,t-1}$

$$y_t - y_t^f = \left(\frac{1-\theta}{\theta}\right)(1-\tau)(e_t - e^*_{t,t-1})$$

The deviation in output about the frictionless level therefore depends upon the unanticipated change in the current exchange rate. In general, $(e_t - e^*_{t,t-1})$ depends upon: (i) the unanticipated components of the exogenous disturbances and (ii) any revisions to exchange rate expectations formed at time t. The assumption that the disturbances are correctly anticipated eliminates the former effect, while by adopting an intervention rule with $\mu_2 = -\alpha_2$, the monetary authority eliminates the effects of the latter, which would otherwise impact through the money market. Hence setting $\mu_2 = -\alpha_2$, ensures that exchange rate expectations will be correct, which in turn implies perfect stabilization of output about its frictionless level. Further, setting the arbitrary parameters $\mu_1 = \mu_3 = \alpha_2$, $\mu_4 = 0$, the money supply rule can be written in the particularly simple form

$$m_t = -\alpha_2 r_t$$

in which the domestic monetary authorities accommodate movement in the demand for money resulting from movements in the domestic interest rate.

An important aspect of these results is that in both cases the rule yields perfect stabilization irrespective of change in exchange rate expectations between time t-1 and time t. Since such changes, if they occur, reflect private agents' perceptions of disturbances occurring at that time, perfect stabilization of output is obtained irrespective of whether the shocks occurring at time t are perceived at that time as being permanent or transitory.

7. WAGE INDEXATION

It is seen from the analysis of Sections 4-6 that for the adopted policy specifications, wage indexation is inessential. All of the optima can be reached by the adoption of monetary policy alone. This is hardly surprising, given the asymmetry of information embodied in the monetary policy and wage indexation rules. At the same time we have shown that wage indexation alone can yield perfect stabilization in the cases of full information and perfectly anticipated disturbances. We now consider whether in the case of unanticipated disturbances, wage indexation rules, based on the same information as the above monetary rules, can achieve the same equilibria. Specifically, we consider the wage indexation rule

$$w_t = w^c_{t,t-1} + \tau_1(p_t - p^*_{t,t-1}) + \tau_2(q_t - q^*_{t,t-1}) + \tau_3(\omega_t - \omega^*_{t,t-1}) + \tau_4(e^*_{t+1,t} - e^*_{t+1,t-1}) \tag{42}$$

That is, wages are indexed to unanticipated changes in the foreign price level, the foreign interest rate, the expected exchange rate, in addition to the domestic price level. Given PPP, this rule is clearly an indexation analogue to the money supply rule (14c).

Repeating the previous analysis, we can show that with white noise disturbances, the choice of intervention parameters τ_1, τ_2, τ_3, τ_4, enables the replication of the equilibria of the previous equilibria to be obtained. The reason is that τ_2, τ_3, can eliminate the foreign variables q_t, ω_t; τ_4 is irrelevant and τ_1 can be chosen by setting $\mu_1 = 0$ in (31) or (34). In the case where private agents observe u_t, v_t, only partial stabilization is obtained, while when neither private agents nor the stabilization authority observe these disturbances, perfect stabilization results.

In the case of initially unanticipated, but perceived permanent disturbances, we cannot get perfect stabilization about the frictionless economy with this more general wage indexation scheme alone, as long as private agents observe u_t, v_t. While indexation can stabilize for u_t, q_t, ω_t, the elimination of the supply shocks requires monetary policy. However, the generalized wage indexation scheme can achieve perfect stabilization when u_t and v_t are not observed by private agents.

The reason why wage indexation may, or may not, yield perfect stabilization can be seen from the supply function. For this purpose, we can set expectations at time $t-1$ to zero. In this case, the deviation in output about the frictionless level is

$$y_t - y_t^f = \left(\frac{1-\theta}{\theta}\right)\left[p_t - w_t + \frac{1}{1+n\theta}E_t(v_t)\right]$$

which is the case that v_t is observed is modified to

$$y_t - y_t^f = \left(\frac{1-\theta}{\theta}\right)\left[p_t - w_t + \frac{v_t}{1+n\theta}\right]$$

In general, p_t is a function of more random variables than just v_t. When v_t is observed, the wage indexation rule (42) contains insufficient independent parameters to stabilize for both p_t and v_t exactly. With disturbances which are perceived to be permanent, the effect of the optimal monetary rule (37a) is essentially to eliminate, through the adjustment of exchange rate expectations, the effects of all random variables other than v_t on the price level. Indeed, the rule ensures that the real wage adjusts by precisely the amount $v_t/(1 + n\theta)$, thereby leading to the perfect stabilization of output about its frictionless level. But with transitory shocks, exchange rate expectations do not adjust and monetary policy is also unable to achieve perfect stabilization.

On the other hand, when v_t is not known, $E_t(v_t)$, inferred from the least squares prediction (16b), is essentially a linear function of the observed disturbances p_t, ω_t, q_t and r_t, upon which the wage indexation rule is based. It is not an independent variable and the rule includes sufficient parameters to neutralize all these random shocks.

8. CONCLUSIONS

This paper has analyzed the interdependence between the optimal degree of wage indexation and optimal monetary policy for a small open economy. We have investigated this relationship under a variety of assumptions regarding: (i) the relative information available to private agents and the (public) stabilization authority; (ii) the perceived nature of the disturbances impinging on the economy. Several conclusions are worth highlighting.

First, if all agents have perfect information, then perfect stabilization can be achieved either by modifying the Karni indexation rule by adjusting wages to the unanticipated change in output, or by an appropriate but very simply specified monetary rule.

Most of our attention has dealt with incomplete information. Where disturbances are unanticipated, we have drawn the distinction between those that are perceived as being transitory (white noise) and those that are perceived as being permanent shifts. In the case of the former, we find that the distortions due to the wage contract can be fully eliminated, thereby replicating the output of the frictionless economy, as long as private agents and the stabliza-tion authority have the same (imperfect) information. On the other hand, for perceived permanent shifts, perfect stabilization is achieved whether or not private agents and the stabilization authority have identical information. In the case where the information sets are identical, there are two sets of policy rules which achieved perfect stabilization. We have also considered the situation in which private agents are unable to decide whether or not a disturbance which has occurred is permanent or transitory and show that with identical information between private and public agents, perfect stabilization can be achieved. This is not so, however, where private agents have an informational advantage.

Finally, we have determined the optimal policies when disturbances are anticipated. We have shown how perfect stabilization may be achieved either by fully indexing wages to prices or by a simple rule accommodating the money supply to changes in the demand for money arising from movements in the domestic interest rate. In both cases, the perfect stabilization obtains irrespective of whether the disturbances are expected to be temporary or permanent.

Our analysis emphasizes the policy redundancy issue. That is, some of the policy coefficients can be set arbitrarily, enabling the policy rules to be specified in many equivalent ways. In all cases wage indexation is inessential, in the sense that the equilibrium can be achieved through monetary policy alone. While this is largely a consequence of relatively rich specification of the monetary policy rule, this is not entirely so. In one important case, where private agents have perfect information and perceive all shocks as being permanent, perfect stabilization, which can be achieved through a very simple monetary policy rule, cannot be accomplished through wage indexation based on equivalent information.

FOOTNOTES

* The constructive suggestions of two referees are gratefully acknowledged.

1. See e.g., Aizenman (1985), Marston (1984). There is also an extensive literature dealing with optimal exchange rate management (optimal exchange market intervention) in non-indexed economics. See, e.g., papers in Bhandari (1985) and the references therein.

2. Suppose the nominal demand for money (specified in logarithms) is $m^d = \phi e + z$, where e = exchange rate (in logarithms) and z denotes all other variables. Wage indexation becomes ineffective if the money supply m is adjusted by a rule of the form $m = \phi e$.

3. We should note that, some authors, for example Flood and Marion (1982), assume that the money supply follows a random walk. However, they do not address issues of optimal stabilization policy.

4. Note that our analysis abstracts from input and input price shocks. These are considered by several authors. A recent paper by Aizenman and Frenkel (1986) considers wage indexation and monetary rules in response to productivity and input shocks under perfect information. Marston and Turnovsky (1985a) analyze alternative wage indexation rules in response to import price shocks, again under the assumption of perfect information. By contrast, Marston and Turnovsky (1985b) analyze the case where the productivity disturbances are firm-specific. They show that if these are observed by the firm alone, perfect stabilization of the economy can be attained by the combination of a wage indexation rule and a rather complicated taxation scheme.

5. This means that instantaneously the firm may not know its own output. Of course once v_t is observed, its output can be inferred, but the point is that this information may become available only after the current production decision is made.

6. Note that our welfare criterion is precisely the same as that introduced by Aizenman and Frenkel (1985) under their information assumptions (our case (iii)). Subtracting (13) from (9) yields

$$Y_t - Y_t^f = (\frac{1-\theta}{\theta})\left[\frac{\ln(1-\theta)}{1+n\theta} + P_t - W_t + \frac{E_t(v_t)}{1+n\theta}\right]$$

which in deviation form is

$$y_t - y_t^f = (\frac{1-\theta}{\theta})\left[p_t - w_t + \frac{E_t(v_t)}{1+n\theta}\right]$$

Minimizing var $(y_t - y_t^f)$ is equivalent to minimizing the loss function (31) of Aizenman and Frenkel (1985).

7. In addition the general solutions for expectations $e^*_{t+1,t}$ include a term containing an arbitrary constant A_t say. This reflects the non-uniqueness of rational expectations solutions. In the case of (21a), A_t must be set to zero to ensure that the solution is stable. In the case of (21b), however, stability considerations alone do not suffice to determine A_t. This can be determined by invoking some additional restriction. Here we adopt the "minimal state representation" procedure proposed by McCallum (1983) and widely used (for some time) by others. This involves picking the rational expectations solution based on the simplest solution and means that $A_t = 0$, independent of stability considerations. The notion that solutions are based on minimum information is appealing in that it embodies the idea that forecaster use scarce information efficiently.

8. In (21b) $z^*_{t-j,t} = z_{t-j}$ for $j \geq 1$, meaning that past values of z are known at time t. The case where expectations are backward-looking, while consistent with rational expectations, is of less economic interest. In the cases we discuss, the expectations are always forward-looking.

9. The fact that $\hat{\tau} \neq 1$ supports the claim made previously that full wage indexation is non-optimal. It can be shown that the minimized (positive) variance obtained under this optimal rule is less than what would be obtained under full wage indexation.

10. Since the disturbances we are considering are exogenous to the model this procedure is perfectly consistent with agents having rational expectations.

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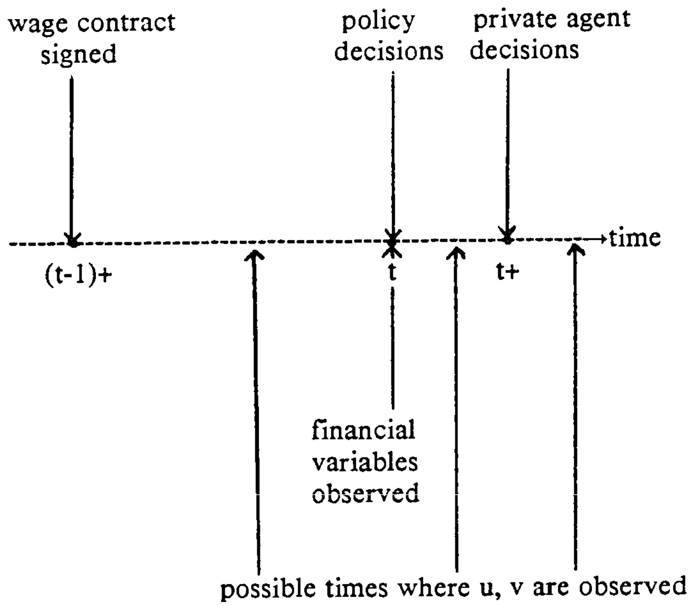

Fig. 1
Timing of Information and Decisions

TABLE 1

UNANTICIPATED DISTURBANCES

	White Noise	Perceived Permanent Shifts
Private Agents observe u_t, v_t	μ_2 arbitrary $\mu_3 = -\alpha_2$ $\mu_4 = -\alpha_2+\mu_1$ $\frac{(1+\alpha_2-\mu_1)\phi}{1+n\theta} = (1-\tau)\left[\theta + \alpha_1\phi(1-\theta) + \frac{\alpha_1 n(1-\theta)\phi}{1+n\theta}\right]$, $\mu_1 \neq 1+\alpha_2$, $\tau \neq 1$ *imperfect stabilization*	$\mu_1 = 1+\alpha_2$ μ_2, μ_3, μ_4 arbitrary τ arbitrary but $\tau \neq 1$ *perfect stabilization*
Private Agents do not observe u_t, v_t	μ_2 arbitrary $\mu_3 = -\alpha_2$ $\mu_4 = -\alpha_2+\mu_1$ $\frac{(1+\alpha_2-\mu_1)\phi}{1+n\theta} = (1-\tau)\left[1 + \frac{\alpha_1 n(1-\theta)\phi}{1+n\theta}\right]$, $\mu_1 \neq 1+\alpha_2$, $\tau \neq 1$ *perfect stabilization*	(i) $\mu_1 = 1+\alpha_2$ μ_2, μ_3, μ_4 arbitrary τ arbitrary but $\tau \neq 1$ (ii) μ_2 arbitrary $\mu_3 = -\alpha_2$ $\mu_4 = \mu_1+\mu_2$ $\frac{(1-\mu_1-\mu_2)\phi}{1+n\theta} = (1-\tau)\left[1+\frac{\alpha_1 n(1-\theta)\phi}{1+n\theta}\right]$ *perfect stabilization*